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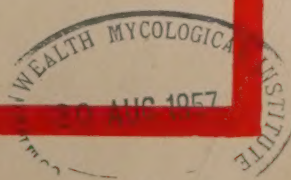
WYE COLLEGE

Department of Hop Research
ANNUAL REPORT

1956

*Copies of this Report may be obtained, price 5/-, from
the Secretary, Wye College, Nr. Ashford, Kent*

(Published July 1957)



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DEPARTMENT OF HOP RESEARCH

INTRODUCTION

This ninth annual report is written at a time which may well prove to be of great importance in the history of the Department. In September 1956, a new outbreak of *Verticillium* wilt was recorded in a hitherto clean College hop garden. Pathogenicity tests are at present being carried out by the National Agricultural Advisory Service, and should these prove the new outbreak to be of the progressive type, the College may have to be regarded as a "wilt farm". Since Wye lies in the wilt-free area of East Kent, such a development must raise major issues of policy, not the least of which relates to the possible risk to hop growers in the neighbourhood.

These issues have already been most carefully considered by a technical committee of the Agricultural Research Council. It is the recommendation of this committee that in the event of Wye College being confirmed as a wilt farm, hop research should continue there using tolerant varieties under a special licence granted by the Ministry of Agriculture, Fisheries and Food. The licence will lay down conditions to ensure the safety of existing commercial hop cultivation in East Kent. This recommendation has been accepted by the Hops Advisory Committee of the Council on which the various branches of the Industry are represented, and its acceptance has been endorsed by the Hops Marketing Board.

There is therefore a possibility that circumstances may force the Department to work with wilt-tolerant varieties only. While this will presumably meet with approval in the large areas of the South-East that are already affected by Progressive Wilt, the West Midlands and East Kent may view such a change in emphasis with some concern. However, growers in these wilt-free areas may rest assured that their particular needs will in no sense be neglected. As far as plant breeding work is concerned, provision for their needs already exists in new wilt-sensitive material in quarantine at Cambridge. With regard to other problems, research at Wye is being so directed as to provide basic data of value to growers of all types of varieties.

The need for such basic information is obvious; most of all, perhaps, in matters relating to hop growth. This aspect of research, which affects all sections of the Department, has received but little attention in the past owing to lack of a suitably qualified worker.

It is therefore with pleasure that a welcome is extended to Mr. I. H. Williams who takes up the post of crop physiologist in the Department in July 1957. He is to make growth studies of the hop which, while not expected to produce immediate results, should prove to be of fundamental value.

The opportunity is taken once again to express the indebtedness of the College to the Agricultural Research Council for its interest in and support of the Department throughout the year, and through the Council to thank the Hops Marketing Board and the Institute of Brewing for their continued support. Grateful acknowledgement is also made of help and co-operation received from East Malling Research Station, the Brewing Industry Research Foundation, the National Agricultural Advisory Service, and the many friends of the College and the Department in the Industry.

DUNSTAN SKILBECK.

June, 1957.

REVIEW OF RESEARCH

H. S. DARLING

Research has continued at Wye on the production of varieties tolerant to Progressive *Verticillium* Wilt, and progress is discussed in the account of the work of the plant breeding section on page 16 of this report.

The original total of more than 3,000 seedlings in the Wye/East Malling Joint Scheme has been reduced to a first short list of 14 varieties. The completion of this short list has been based on rigorous wilt-testing by East Malling Research Station, on careful selection on cultural characters at Wye and on physical examination of dried samples in the Borough. It is hoped that, with the help of results of small-scale brewing trials by the Brewing Industry Research Foundation, a final selection will be made from this short list in 1957 of three or four varieties for full scale farm trials. These final selections will then undergo intensive propagation at Wye to provide the large numbers of sets required for the planting of farm trials scheduled for the winter of 1959-60.

Some of the first triploid derivatives of Bullion are at present undergoing wilt test at East Malling and nearly 1,000 triploid seedlings from tetraploid Fuggle N, mostly from crosses involving wilt-tolerant males, were raised in 1956 and are now growing in the Nursery Garden. Successful pollination of diploid and tetraploid Eastwell Golding and diploid Fuggle N by wilt-tolerant males was achieved.

Attention is also being given to the production of varieties with field resistance to Downy Mildew, *Pseudoperonospora humuli*. A few apparently resistant varieties were produced accidentally in past plant breeding work on other problems (see page 54), but only one of these, CC77, shows any commercial promise. A new project, still in its preliminary stages, will make use of highly resistant material obtained from Dr. Zattler in Germany. The fulfilment of this project awaits the development of techniques by the pathologist for assessing the degree of resistance of the resultant seedlings. As indicated on page 42, this work is in hand and satisfactory progress is being made.

The presence of Progressive Wilt at Wye has necessitated the establishment of quarantine gardens, and, as described on page 11,

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these have been successfully planted in the Cambridge area. This work, while essential to the Department, is inevitably unfruitful as far as research is concerned. Its burden has fallen heavily on the plant breeding staff and has added to the difficulties inherent in their research.

The ill effects of wilt have not been confined to the plant breeding section. The account of the work of the field experiment and plant nutrition section given on page 21 makes it clear that the loss through this disease of the height of wirework and spacing experiment is keenly felt; the more so since the prevailing uncertainty as to the wilt status of the Wye College farm has so far prevented the replanting of this valuable trial.

This uncertainty has also prevented the completion of plans for a new long-term manurial trial which it had been hoped to establish at Wye in the near future. This difficulty has been circumvented through the kindness of Guinness Hop Farms Ltd., on whose farms three new long-term manurial trials will be laid down in 1957. These are NPK trials testing three levels of each nutrient in factorial experiments of 3^3 design.

In the general account of the Wye College hop crop on page 14, mention is made of a gale on July 29th, 1956; it is also discussed on page 23 and is referred to elsewhere in this report. This gale caused very severe damage to all hop experiments and so affected plant growth and yields as to make the 1956 results of the Wye Field variety trial plots of little value. The bine-cutting trial was also adversely affected.

Work began in 1956 on the estimation of the effectiveness of spraying techniques in terms of the amounts of chemical deposited on standard areas of leaf surface. Copper deposits resulting from a range of commercial treatments (including high and low volume spraying) were found to vary from 1.0 to 27.0 micrograms Cu per sq. cm. of leaf surface. This work is to be extended in 1957.

Preliminary work by the Brewing Industry Research Foundation in 1955 suggested that the incidence of Nettlehead disease might be due to high concentrations of nickel in the plants. A sand culture experiment on nickel nutrition carried out at Wye to investigate this possibility is described on page 50. Its results indicate that while high concentrations of nickel caused definite toxicity symptoms, they did not give rise to any symptoms resembling Nettlehead.

As in 1954 and 1955 a survey was made of a series of pairs of hand- and machine-picked pocket samples from the 1956 commercial English hop crop. The results, given on page 44, confirm the findings

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of the earlier surveys. They show that machine picking was associated with an average loss of 1.41 per cent. total soft resins, amounting to about one-eighth of the resin content of the hand-picked samples. Much of this loss was due to the effect of machine picking on cones that were otherwise whole and undamaged. The survey also showed the leaf and stem content of machine-picked hops to be significantly greater than in the hand-picked samples. In 1956 the degree of resin loss through machine picking and the level of leaf and stem content in all samples were much higher than had previously been recorded. These increases presumably reflect the very adverse weather conditions of the 1956 season.

The National Institute of Agricultural Engineering carried out research in 1956 on hop drying installations of conventional and advanced design, and results will be published in due course. It had been expected that this body would also follow up its promising preliminary work on picking machines carried out in 1955. Unfortunately this was prevented by staff shortages which still prevail sufficiently in 1957 to limit hop research by the N.I.A.E. in this year to a study of drying problems. It is hoped that sufficient staff will be available to allow work on picking machines to recommence in 1958.

The account of work on pests and diseases given on page 36 suggests that under the wet and stormy conditions of the 1956 summer, soil application of the systemic insecticide dimefox was the most satisfactory method of controlling hop aphid in the majority of varieties. This treatment can be carried out under all weather conditions, in marked contrast to sprays which demand calm dry weather for effective application.

In a few varieties dimefox fails to give good results. In some, such as Keyworth's Midseason (OR55), commercial experience has shown that the plants may fail to absorb and translocate enough of the insecticidal material to give effective aphid control. In other varieties the chemical can be dangerously phytocidal. While this effect has not been found to be of importance in named commercial varieties, it has had drastic results with new plant breeding material. Tests in 1956 at Wye have shown that mature hills of susceptible varieties can be killed by normal dosages of the compound.

Of the two systemic insecticides normally used as sprays, "Metasystox" in 1956 proved itself to be more effective than schradan, due probably to the additional contact insecticidal effect of the former. This point has been accepted by the trade and commercial formulations of schradan are now available in which a contact insecticidal ingredient has been incorporated.

None of the systemic insecticides appeared to be as effective in 1956 as in previous years. This was probably due mainly to unfavourable weather conditions hindering the absorption and translocation of the insecticides. The possibility should not be overlooked, however, that strains of the hop aphid may be appearing which are in some degree resistant to these organo-phosphorus compounds.

Spraying trials against Downy Mildew failed to yield full results because of gale damage to the experimental plots. Observations made during the growing season indicated that captan gave at least as good control of the disease as standard copper fungicides.

Dry-hopping trials by the Brewing Industry Research Foundation using captan-treated hops from the 1956 spraying experiment, showed clearly that under such conditions this new fungicide can cause tainting in the beer. This finding is in contrast to the results of the brewing trials carried out with hops from the 1955 experiment which showed that, even when heavily contaminated, captan-treated hops caused no tainting when used in the copper. It is therefore unfortunately necessary to warn growers that this fungicide should not be applied to ripening cones and therefore should not be used after mid-August.

Research on Downy Mildew is being developed; an essential part of this work is the maintenance of supplies of the infective stage of the fungus throughout the year. Since it is an obligate parasite this has entailed the growing of hops under glass during the winter; an account of this new venture is given on page 73.

Work on this disease has included research on techniques for assessing varietal resistance, and a survey of rootstock infection in Goldings which is described on page 65. This survey has shown that standard control measures applied to the aerial growth only, which were efficient enough to make possible heavy yields of high quality hops, have not prevented many of the rootstocks from rotting in a manner usually attributed to attack by Downy Mildew.

Research on the organic chemistry of the hop plant is discussed on page 27. While chromatographic investigations have made steady progress, experiments to study the role of sugars in resin formation were largely invalidated by adverse weather conditions. This work is to be continued and extended in 1957. A small-scale exploratory experiment was made to investigate the use of radio-active phosphorus in tracing the uptake of chemicals by hop plants. This technique may be expected to prove of value in studying the action of systemic insecticides.

Appendix II on page 81 is published by kind permission of the Brewing Industry Research Foundation; in it a valuable account is given by Dr. G. A. Howard of the recent advances in hop chemistry to which the Foundation has so largely contributed. The chemistry of the alpha and beta resins is fully discussed and the importance of variety in determining the level of cohumulone, the main bittering agent, in the alpha resin is clearly brought out. Wye varieties of the American type such as Pride of Kent and Bullion have a relatively large cohumulone fraction which in conjunction with their high total resin content accounts for their great bittering power. By contrast, Northern Brewer, which in spite of its high resin content and its share of American ancestry, is English in character, has the same relatively low level of cohumulone in its alpha resin as Fuggles and Goldings.

Detailed study of the essential oil fraction, which is responsible for hop aroma, is at present in progress at the B.I.R.F. This important fraction, which is less than 1 per cent. by weight of the dried hop sample, is of a very complex nature and contains about 50 different compounds. These are divided chemically into two main groups: the hydrocarbons and the oxygenated compounds. The composition of the former is largely decided by variety; that of the latter is less affected by variety and more by factors within the control of the industry such as the stage of ripeness at picking time, the temperature and duration of drying, and conditions during storage. The role of hop oils in the quality of beer has not yet been fully determined. In copper-hopping it appears likely that the high boiling point hydrocarbons may be of great importance. In dry-hopping, where delicacy in hop aroma is demanded, other compounds may play a major part.

Appendix II closes with a brief reference to the hop tannins, a group which appears to be even more complex than the hop oils. It contains more than 80 distinct compounds, some of which may prove to be of importance in the brewing process.

Appendices III and IV comprise articles on the 1956 hop season as seen from the commercial grower's viewpoint. These are written by the Hops Advisory Officers of the National Agricultural Advisory Service and are published by the courtesy of the Ministry of Agriculture, Fisheries and Food. In addition to describing the salient features of a difficult season they present a picture which reflects the changes induced by the scarcity and high cost of labour. Chemical stripping of unwanted lower foliage is becoming common; machines are steadily replacing the hand picker, especially in the West

Midlands, and in 1956, between one-third and one-half of the total English crop was picked by machine; instrumentation is coming in to help the grower in the often difficult task of drying machine-picked hops; a demand exists for a continuous drier and a model is on sale. Such developments are noteworthy and the Department is grateful to Mr. Chater and Miss Jary for placing them on record in this report.

In conclusion, thanks are expressed to those who have helped the Department during the year. Grateful acknowledgements are due to the Guinness Hop Farms Ltd., and other growers who have provided facilities for extensions of departmental research; they are also due to Wild, Neame & Co., to Wigan Richardson & Co., to Wolton, Biddell & Co., and to William Younger & Co. Ltd., for examining hop samples from various lines of experimental research. Finally, thanks are due to the National Agricultural Advisory Service and to the National Institute of Agricultural Botany for their co-operation and help in the establishment and maintenance of the quarantine gardens in the Cambridge area.

PROGRESSIVE *VERTICILLIUM* WILT OF HOPS AT WYE COLLEGE AND THE ESTABLISHMENT OF QUARANTINE GARDENS

H. S. DARLING

In the winter of 1955-56 the hops in the western six acres of Wye Field garden were grubbed and burned and the area grassed down with the object of confining and neutralizing the outbreak of Progressive *Verticillium* Wilt known to be present there. Unfortunately the discovery of a single hill infected with *V. albo-atrum* in the hitherto wilt-free Nursery Garden in September, 1956, suggests that this object may not have been achieved. A pathogenicity test is to be carried out by the National Agricultural Advisory Service to determine the status of this new infection, and the result of this test should be available by July or August, 1957. Meanwhile the case is being regarded as one of suspected Progressive Wilt and suitable precautions have been taken under the guidance of the N.A.A.S.

No other case of *V. albo-atrum* in hops was recorded at Wye in 1956.

As mentioned on page 18 of the Departmental Report for 1955, it was decided on account of the wilt outbreak to establish hop quarantine gardens at a distance from Wye. This work has three objects as follows:

- (a) To maintain stocks of valuable wilt-sensitive plant breeding material on clean soil away from Wye under greatly reduced risk of loss from Progressive Wilt.
- (b) To make available as soon as possible to wilt-free areas (notably the West Midlands and East Kent) the new wilt-sensitive hops produced by recent work at Wye. These include Golding and Fuggle clonal selections as well as promising unnamed varieties.
- (c) To provide a safe outlet from Wye for wilt-free material of new varieties produced by current and future plant breeding research.

It was decided that the Cambridge area was suitable for quarantine purposes and through the kindness of the N.A.A.S. two isolated gardens were successfully planted at Cuckoo Pastures Experimental Husbandry Farm, Boxworth, Cambridge, in the winter of 1955-56. The establishment of these gardens, including the erection of wirework, was carried out by Wye College staff. This work and subsequent care and maintenance has been the responsibility of the plant breeding section.

The smaller of the two gardens at Boxworth, containing about 160 hills, was planted with mosaic-sensitive varieties, including material of the 23 Golding selections of which large-scale plot trials are now beginning at Wye. The larger of the gardens, containing about 450 hills, was planted with mosaic-carrier varieties comprising the main plant breeding collection from the Nursery Garden at Wye. This includes material of basic genetic value together with the range of new Fuggle selections to which reference has been made in previous departmental reports.

The gardens made good growth during 1956, being cared for by local field staff under the supervision of the Wye plant breeders who visited Boxworth as often as circumstances permitted. Both gardens were inspected by the N.A.A.S. in September when all plants were found to be apparently free from *Verticillium* Wilt.

It is hoped that the varieties at Boxworth will complete a two-year quarantine period successfully at the end of 1957. Each hill will then be tested for *V. albo-atrum* by N.A.A.S. pathologists and if no disease is found, material from Boxworth will be used to establish the collection on its permanent site at Luddington Experimental Horticulture Station near Stratford-on-Avon in the winter of 1957-58. The Boxworth gardens will then be free to receive further planting material for quarantine from Wye.

All the material quarantined at Boxworth came from the Nursery and Silks gardens at Wye. At the time of the Wye Field wilt outbreak, there was a large amount of mosaic-carrier plant breeding material growing in the eastern half of this garden. Owing to its proximity to the outbreak it was decided that the risk of its being infected was too great to allow it to be planted with the material from the other College gardens. Arrangements were therefore made to quarantine it separately, and through the kindness of the National Institute of Agricultural Botany a third quarantine garden was successfully planted in the Cambridge area in the winter of 1956-57. This garden, which contains about 700 hills, was established on the N.I.A.B. farm at Lolworth, the erection of

the wirework and the planting being carried out by Wye College staff. As with the Boxworth gardens, care and maintenance is the responsibility of the plant breeding section.

The material planted in this Lolworth garden is largely made up of unnamed, wilt-sensitive, mosaic-carrier varieties bred by Professor Salmon, of which a number had almost completed their plot trials at the time of the wilt outbreak. They include a series of conspicuously early varieties whose other qualities are still to be assessed. They also include varieties about which much is already known, such as OQ14, a relative of Northern Brewer, which won praise in the 1956 New Varieties Exhibition, and CC77, a hop with an American background, which combines commercial promise with considerable field resistance to Downy Mildew. When the quarantine of the varieties now at Lolworth is completed, the material will be moved elsewhere and this garden will then be closed down.

REVIEW OF THE 1956 HOP SEASON AT WYE COLLEGE

H. S. DARLING

The climate of the 1956 growing season at Wye was poor. The coldest February in fifty years was followed by a late spring with a cold dry April. In May conditions improved slightly, but from June onwards the summer was cold and wet with consistently low figures for sunshine. Meteorological data for Wye for April-September, 1956, are tabulated below.

	Rainfall Inches per month		Sunshine Hours per day		Mean Temperature °F.	
	1956	1935-56	1956	1935-56	1956	1935-56
April ..	0.90	1.60	5.9	5.9	43.6	47.6
May ..	0.75	1.97	8.4	7.0	54.3	53.0
June ..	2.86	1.73	5.5	7.4	55.9	58.6
July ..	2.14	2.20	5.3	6.8	61.4	61.8
August ..	4.04	2.53	5.3	6.4	57.5	61.8
September ..	1.91	2.31	4.3	5.1	59.6	58.0

Under such conditions a good crop was unlikely, and in normal circumstances moderate yields of poor quality, similar to the 1954 harvest, were to be expected. On July 29th, however, a south-westerly gale of exceptional strength (Force 8) did very great harm to the crop, destroying the lateral fruiting branches at a time when the maturity of the plants precluded the possibility of further lateral growth. This wind damage was such as to mask most of the other ill effects of the season and to force yields from the College gardens down to the very low average of just over 7 cwt. dried hops per acre, compared with the average of 21 cwt. per acre obtained in 1955.

The gale damage incurred on July 29th seriously interfered with the field work of the Department by reducing plant growths and yields to a common level and largely eliminating varietal and experimental treatment effects.

Downy Mildew disease appeared early in the season causing large numbers of spikes and some leaf infection in May. Owing to the poor summer the crop was unable to grow away from the disease and much spiking and a full spray programme was necessary to keep it under control. Copper sprays were applied seven times from June onwards, the last being on August 20th. In spite of evidence of cone infection elsewhere, a clean crop was harvested from the College gardens in September.

Mould disease was kept under good control by repeated treatment with sulphur. A potentially severe aphid attack developed early in June and was satisfactorily controlled by systemic insecticides. No attack by red spider was noticed.

As described on p. 11 a single case of suspected Progressive Wilt was discovered in the Nursery Garden in September. No other case of *Verticillium albo-atrum* in hops was recorded at Wye in 1956.

Picking started on September 6th and ended on September 19th. The small light crop was harvested without difficulty in nine picking days under reasonably good weather conditions.

The loss through wilt in 1955-56 of six acres of high yielding commercial varieties in Wye Field reduced the potential 1956 crop by nearly half. This loss was increased by gale damage and only 8,500 bushels of green hops were picked in 1956 compared with 40,900 in 1955. The hops weighed badly on drying to give an average ratio of 127 bushels per dried cwt. compared with 115 in 1955. The total yield of dried hops as weighed at the College oast in September was only 67 cwt. compared with 355 cwt. in 1955. Of this total, 23 cwt. were Goldings, the balance being unnamed hops from the plant breeding rows and plots.

The crop, though small, was of surprisingly good quality considering the season. The average price obtained for the College Goldings was only 6s. below the top of Grade I. Nearly two-thirds of this section of the crop were in fact placed at the top of Grade I, the remainder being slightly down-graded on account of wind damage.

As mentioned on p. 17 of the Departmental Report for 1955, the eastern 4 acres of hops in Wye Field were due to be grubbed and burned in the winter of 1956-57. Owing to the case of suspected Progressive Wilt referred to above this action has been postponed. If the new outbreak is confirmed, the College may have to be regarded as a "wilt farm" and the future of Wye Field will then be reconsidered.

PLANT BREEDING SECTION

REVIEW OF THE YEAR'S WORK

R. A. NEVE and R. F. FARRAR

GENERAL

The final stage in the reorganization of the Nursery Garden was completed in June, when the last batch of material saved from the old seedling collection was planted out in the new positions. With this major operation completed, there was every prospect of the work of the section settling down to several years of steady development along the lines of progeny testing made possible by the new layout. These hopes seemed further justified when in the following month nearly a thousand triploid seedlings of Fuggle N were planted out, each in its family group, and interplanted with normal Fuggle N plants for comparison.

A temporary check was received at the end of July when the severe gale did much damage to the hops, and made the task of selection in all cases difficult, and in some cases quite impossible.

Far more serious, however, was the discovery of a case of *Verticillium* wilt in the Nursery Garden at picking time. If this should prove to be the progressive strain we shall be faced with a new set of problems requiring solution. Provisional plans have been made to meet the new situation, but at the best they will impose limitations on the type of plants it will be possible to grow at Wye, and as a result the time needed for certain breeding projects may be longer than was originally planned. Nevertheless it is very strongly felt that such delays would be many times less than those that would be involved if an attempt was made to start up a new hop breeding station on gardens at present free from *Verticillium*.

The occurrence of *Verticillium* in the Nursery Garden emphasizes still more the value of the genetic collection in a quarantine garden outside the normal hop growing areas. This collection grew well during the season and no sign of *Verticillium* was detected.

The wirework for a second quarantine garden was erected in the autumn, while cuttings of the Wye Field material to be transferred were grown into sets during the season.

Work on these outstations involves a considerable amount of time, and frequently clashes with busy periods at Wye, but since

it forms an essential corollary to the work here this inconvenience has to be accepted.

VERTICILLIUM WILT TOLERANCE

Wye/E.M.R.S. Joint Scheme

The number of varieties in the scheme at the beginning of the year was 77, one of which was maintained only at East Malling Research Station. Of these, eight were tested for wilt-tolerance at a 30-plant level, at East Malling. Two merchants were each sent a series of 38 box samples for commercial assessment, and P.V. determinations were carried out at Wye on 35 samples. During 1955 and 1956, a total of 17 samples were submitted to the Brewing Industry Research Foundation for small scale brewing trials.

At the end of the season, five varieties were discarded for wilt susceptibility, one for mosaic sensitivity and 31 for lack of commercial promise. The mosaic-sensitive variety was the one being maintained at East Malling, therefore all selections are now held at Wye. The 31 selections showing lack of commercial promise were discarded as a result of several seasons records.

Owing to the gale damage during the summer, crop samples were poor. In spite of this, several of the box samples submitted to the merchants received favourable comments. The resin analysis results, were on the whole, very low; alpha-resin being the worst affected. Of those varieties which had previous analyses for comparison, only a few maintained their level.

A row of 3-hill blocks of each selection was established in the Nursery Garden, to replace the plots in Wye Field in the event of these being grubbed. The selections planted at the outstation at Boxworth have become well established.

As a result of selection up to the present, 40 varieties remain in the scheme. Of these, 14 have been subjected to all the preliminary tests, trials and analyses, and are being considered as the first series for selection for farm trials commencing in 1960. With this in view, these 14 varieties will be intensively propagated during 1957, and it is the aim to have 1,200 sets each of three or four final selections, available by the winter of 1959.

Discussions have taken place with East Malling staff concerning the establishment and running of the farm trials and a procedure has been agreed upon. The trials will be in the form of 400-hill plots of each variety chosen, sited on a range of soil types, and grown under normal commercial conditions. Hop growers with suitable

gardens on wilt infected land, have agreed to accommodate trial plots.

During June and July, two formulations of dimefox were soil applied to 21 mature hills of nine varieties, young plants of which had been badly affected by this systemic insecticide in 1955. Strengths of 0.25, 0.50 and 0.75 grammes per plant in 4 fluid ounces (114 ml.) of water, were used; 0.50 being the normal commercial strength. One application was made to each hill. Varying degrees of damage were recorded, ranging from complete destruction of the bines, to slight marginal necrosis of leaves with later growth unaffected. Subsequent examinations have shown that in all cases where the bines were destroyed, and in some where the damage was severe, the hills have failed to survive. In the case of four of the hills which were destroyed, the normal commercial dose was applied; even where the hill survived, the 0.50 application caused, in some cases, a degree of damage sufficient to reduce the crop. No significant difference was noted between the effects of the two formulations of dimefox. This phytocidal effect again proved to be varietal, and stresses the importance of testing any new variety for such susceptibility, before it is released to growers.

Nonsuch (OB53) × wilt-tolerant males

From the three crosses made in 1952, and one made in 1953, eleven male and one female seedlings have been retained. All will be submitted to wilt test in due course.

Tetraploid Bullion × wilt-tolerant males

Of the six families resulting from crosses made in 1953 between tetraploid Bullion and six diploid wilt-tolerant males, 30 promising female seedlings have been retained, and will be established as 3-hill blocks for further field observation.

Tetraploid Fuggle N × wilt-tolerant males

Some 580 seedlings from crosses between tetraploid Fuggle N and six wilt-tolerant males were raised and planted out. Growth was good and some plants produced sufficient cones to provide samples for seed content determinations. A further 400 seedlings were planted out which were open pollinated, but with a good chance of wilt-tolerant males having been involved in their parentage.

New Crosses

Pollination of diploid and tetraploid Eastwell Golding and of diploid Fuggle N by wilt-tolerant males was carried out successfully.

DOWNY MILDEW RESISTANCE

Seedlings from open pollination of two of Dr. Zattler's Downy Mildew resistant varieties were raised and made available to the pathologist for testing. Breeding for resistance to this disease will only be possible when a satisfactory method is available for estimating the degree of resistance of individual plants.

OTHER SEEDLING FAMILIES

Seedlings from open pollination of the yellow mutant form of Brewer's Gold were planted out and comprised 44 green and 44 yellow plants. This ratio suggests that the mutant form is dominant to the normal green type. This character may be of value as a marker gene in later work.

POLYPLOIDY

No new colchicine treatment was carried out, but checking of material from earlier treatments was continued.

Samples of diploid and polyploid hops were collected for seed content determinations. They included samples from the young triploid seedlings of Fuggle N, and it is planned to study variations in these plants over a number of seasons to determine whether fertility varies with the age of the plant.

The resin contents of seedlings from diploid Bullion $\times$ OR80 were compared with those from tetraploid Bullion $\times$ OR80. No marked difference could be detected between the two families.

Pollination of diploid Fuggle N by a triploid male was carried out to determine the amount of seed set and the ploidy of any seedlings produced. The object is to determine whether such males would be a useful adjunct to the triploid females, in the production of seedless hops. No definite conclusions could be drawn by comparing single samples, but the differences indicated that the method might be useful and further investigations are justified.

POLLINATION METHODS

It was decided to rely entirely on the use of cellophane bags in the glasshouse for carrying out this season's pollinations. A method which involved bagging the head of the main bine was particularly

successful, the two cases in which it was used each yielding over 650 good seeds. The bagging of laterals produced variable results, the best instance yielding nearly 400 seeds, the worst being complete failures.

GERMINATION

Germination of seed was poor, only 1,273 germinating from a total of 3,625 sown, or 35 per cent.

It is of interest that a box of seeds, intended as an exhibit at the county show, was sown in May, 1956, and germination was nil. The box was kept in the glasshouse, however, through the winter and at the end of February, 1957, 135 seedlings germinated. All appeared within a few days and not spread over two or three weeks as frequently occurs with normal sowings.

Similar instances have occurred in the past when seeds have been sown too late, but this case serves to emphasize the lack of knowledge concerning germination of hop seeds, and the most suitable time to sow in order to obtain maximum germination.

FIELD EXPERIMENTATION AND PLANT NUTRITION SECTION

REVIEW OF THE YEAR'S WORK

F. C. THOMPSON, F. H. BEARD and E. G. CRIPPS

GENERAL

The establishment of new field trials at Wye has been delayed by the developments in the wilt position. Steps have been taken, however, to propagate planting material and to organize the supply of poles and wirework to enable a start to be made on new trials as soon as possible.

Within the limits imposed by experimental treatments, the hops in the field trials at Wye are grown commercially, and this section is responsible, with the Head of the Department, for the general management of the crop. An account of the growth of the hop crop at Wye from this aspect, is given on p. 14.

The section is also responsible for outside lectures of a general nature and in the past year talks have been given by Mr. Thompson (joint meeting of the Incorporated Brewers' Guild and Institute of Brewing) and Mr. Beard (three meetings of Young Farmers' Clubs). Mr. Thompson and Mr. Beard also assisted in staging and demonstrating at the "Barley Mow" exhibit organized by the Institute of Brewing at the Kent Agricultural Show.

WYE FIELD VARIETY PLOTS

The crops from 36 varieties were picked and dried separately, giving information on yield and bushel/cwt. ratio and providing material for market valuation and brewing trials. The results are given in Table 1. The crop was badly and unevenly affected by gale damage and the yield figures, in consequence, must be regarded as very untypical.

During the year observations were made on plant growth and records taken of the incidence of disease on these plots. A summary of the information obtained on Downy Mildew incidence over the years 1950-56 is given on p. 54.

TABLE I
WYE FIELD VARIETY PLOTS, 1956

Plot	Variety	Date Picked	Hills	Bush.	Dry Wt. (lb.)	Yield (cwt. per acre)	Bush. per cwt.	Effect of Gale.
3	94a	Sept. 17	33	27	25	8.18	121	Damage to heads.
4	EE64	" 17	40	19	19	5.13	112	Severe damage to laterals.
5	OB6	" 19	38	36½	31	8.81	132	Moderate damage.
7	WFG66	" 19	36	5½	9	2.70	68	Very severe damage.
8	OQ14	" 18	42	85	52	13.37	183	No damage.
9	WFB135	" 18	39	37½	89	12.33	103	Little damage.
16	"	" 18	39	44	27	8.10	120	Little damage except to heads.
10	WFH6	" 17	36	29				
11	WFG19	" 17	40	36	32	8.64	126	Ditto.
12	CC23	" 17	36	36½	35	10.50	117	Moderate damage.
15	WFD20	" 17	40	61	56	15.12	120	No damage.
19	EE14	" 17	39	19½	14	3.88	156	Severe damage.
22	AOV52	" 19	39	73½	69	19.11	119	No damage.
23	WFB4	" 17	37	29	25	7.30	130	Damage to heads.
25	WFF90	" 17	38	26	29	8.24	100	Damage to heads.
26	X111	" 19	39	22½	19	5.26	133	Severe damage but some recovery.
27	OV125	" 17	39	36½	27	7.48	151	Damage to heads.
29	OW92	" 18	42	72	69	16.86	117	No damage.
31	R20	" 17	40	28½	24	6.48	133	Severe damage.
34	WFB16	Aug. 29	40	32	36	9.72	100	Slight damage.
36	WFB26	Sept. 18	30	35	34	12.24	115	No damage.
37	WFB66	" 18	39	56½	47	13.02	135	Light damage to heads.
38	OM17	" 17	40	30½	26	7.02	131	Much damage to laterals.
42	WFB145	" 17	34	18½	18	5.72	115	Severe damage.
43	OT22	" 18	39	75½	67	18.56	126	No damage.
45	OZ97a	" 19	39	40½	37	10.25	123	Some damage to heads, but had made a good recovery.
46	AOR43	" 17	40	24	27	7.29	100	Severe damage.
47	DD57	" 17	39	42½	—	—	—	—
50	FF59	" 19	38	52½	49	13.93	120	No damage.
56	OR47	" 17	55	32½	27	5.30	135	Severe damage.
57	X69	" 19	40	94	70	18.91	150	No damage.
59	WFC130	" 17	40	35½	36	9.72	110	Moderate damage.
64	OR38	" 18	41	66½	62	16.34	120	No damage.
65	DD12	" 17	39	30	30	8.31	112	Damage to heads.
69	ACC5	" 17	40	19	17	4.59	125	Severe damage to heads.
70	K31	" 17	58	22½	22	4.10	115	Severe damage.
71	CC77	" 18	42	68	66	16.98	115	No damage.
74	OL42	" 18	38	16½	17	4.83	109	Moderate damage.
77B	OT100	" 17	35	17½	16	4.94	123	Severe damage to heads, moderate to laterals.
78	AA70	" 18	47	55½	50	11.49	124	Slight damage.

THE TESTING AND SELECTION OF FUGGLE AND GOLDING CLONES

An ample stock of planting material of the Golding selections has now been built up and will be established in replicated plots in Silks Garden in 1957.

Planting material of the Fuggle selections is being held until land becomes available on the clarification of the wilt position.

OBSERVATION TRIALS WITH NEW VARIETIES OF HOPS

At Maplescombe the grower, unfortunately, found it necessary to grub the plots owing to reduction in hop acreage following on quota restrictions.

At Sissinghurst the varieties now under trial are Bullion, Northern Brewer, Norton Court Golding and Early Choice. Of these Bullion has continued to do well on this soil and Northern Brewer is also well established and making satisfactory growth. Norton Court Golding has continued to make weaker growth than Northern Brewer and there seems nothing to recommend it over its sister seedling, on this soil. Early Choice made weaker growth than usual in 1956, and was no earlier in season than Northern Brewer.

There seems to be little doubt that from field observations on growth, coupled with market demand, the only Salmon (Wye) varieties which could be generally recommended to growers at the present time are Bullion and Northern Brewer. There is a place for a good, early hop but this is better filled at present by one of the early Fuggle selections than by Early Choice.

In future the emphasis in outside observation trials initiated from Wye is likely to be on the testing of new wilt-tolerant varieties by the plant breeding section.

THE EFFECT OF CUTTING THE BINES AT PICKING TIME

Owing to severe gale damage the yield of hops on these plots was abnormally low being of the order of 7 cwt. per acre, but yield data were obtained from the Petham and Early Bird varieties. In contrast to 1955, no yield difference was found, with the Petham variety, between the plots where the bines were cut at picking time and those where the bines were allowed to ripen off before cutting in November. With the Early Birds, however, the plots cut at picking time showed a significant drop in yield of 1 cwt. per acre dry hops.

The plants in these plots have now had to be grubbed, to free land for other experiments, but the problem is to be investigated in greater detail in a new experiment to be laid down by the N.A.A.S. on the Rosemaund Experimental Husbandry Farm, Hereford. In the course of this grubbing an opportunity was taken in collaboration with the pathologist to assess the amount of Downy Mildew infection in the hills, and a report on this survey is given on p. 65.

GRASSING DOWN TRIALS

Growth of hops in grass in 1956 was generally very fair, in contrast to the severe checks to growth experienced in 1955. Nevertheless, the grassed hops were generally considered to have made rather weaker growth than comparable arable hops. There

leaf, while with high volume the deposits ranged from 9 to 27 micrograms Cu per sq. cm.

A copper dust treatment, applied at weekly intervals, gave small deposits of copper ranging from 0.5 to 3.0 micrograms Cu per sq. cm. of leaf on the 6th day after application.

It is planned to extend these preliminary investigations, in 1957, in an attempt to obtain more precise data on the level of leaf copper deposit required for satisfactory Downy Mildew control.

LABORATORY WORK

A full programme of laboratory work has been maintained. About 150 soils have been analysed for exchangeable bases and exchange capacity, involving some 1,000 separate determinations. A further series of soil samples has been analysed for available boron content. The programme also includes the full mineral analysis of some 150 samples of leaves from manurial trials, including trials at the Rosemaund Experimental Farm and a further 100 samples of leaves and cones from pot experiments, for boron content. In addition to mineral analysis, 35 leaf samples have been analysed for copper content in connection with spraying trials carried out by the plant pathology section. Finally, Mr. E. Chittenden, technical assistant in the section, has carried out the physical analysis of over 50 samples of hand- and machine-picked hops in connection with a survey of the cone breakage and resin loss associated with machine picking.

REFERENCES

- CRIPPS, E. G. and WESTON, E. W. (1956). A note on the effect of boron on the resin and sugar contents of the hop cone. *Rep. Dept. Hop. Res. Wye Coll. for 1955*, p. 102.

ORGANIC CHEMISTRY SECTION

REVIEW OF THE YEAR'S WORK

E. W. WESTON

CHROMATOGRAPHY

Continuing the work of last year (1) the main effort was directed towards isolating in quantity, material which could be identified as giving definite spots during the paper chromatography of ethyl acetate-soluble material from hop leaves. Of the many spots which were observed on a two-way chromatogram only those which gave a yellow fluorescence have yet been separated definitely.

Initially the method of separation tried was that of chromatography of the ethyl acetate-soluble fraction on large sheets of paper. The extract was spotted along the starting line and when developed, coloured bands were observed under ultra-violet light. The papers were dried and the various bands cut out. In this way a partial separation was made. It was found, however, that very little of the material on the strip of paper could be removed again. Extraction of the strip, rolled and placed in a soxhlet extractor, gave in most cases a small quantity of yellowish gummy material. There was, however, still much of the material left behind even after several days continuous extraction. This was shown by fuming the extracted papers with ammonia, when a strong yellow colour was obtained. A number of solvents were examined including methanol, ethanol, methanol and acetic acid, and ethyl acetate, but none effected complete removal.

A simple method in which the strip hung from a trough in a chromatography tank and solvent ran down the strip, likewise removed a portion of the material. After using a number of solvents in this manner it was found that solvents with a high water content were most effective and 2 per cent. aqueous acetic acid was then used as being most convenient.

The method was tedious, however, and attention was turned to cellulose columns. Originally the solvent used for developing these was 10 per cent. aqueous acetic acid, but the bands could not be clearly seen during development even when irradiated with ultra-violet light, and therefore the column had to be eluted in

leaf, while with high volume the deposits ranged from 9 to 27 micrograms Cu per sq. cm.

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The method was tedious, however, and attention was turned to cellulose columns. Originally the solvent used for developing these was 10 per cent. aqueous acetic acid, but the bands could not be clearly seen during development even when irradiated with ultra-violet light, and therefore the column had to be eluted in

conjunction with a fraction cutter. Even with this technique only small quantities of material were eluted and usually formed gummy residues. Chromatographing a little of these eluates on paper indicated that there was much impurity.

When the cellulose column was developed by ethyl acetate containing 5 per cent. acetic acid and just saturated with water, the bands were observed as they moved down the column and collected separately. The eluted fractions after evaporating to dryness, in many cases gave a crystalline material which was washed free of gummy material with methanol. Many of the substances were much less easily soluble in methanol once they had been crystallized.

After washing with cold methanol they were recrystallized by taking up in a little hot methanol, cooling, and allowing the methanol to evaporate in a small test tube. Crystals formed on the side of the tube and after pouring off the mother liquor they were washed off with a little cold methanol and filtered.

Small quantities of these substances were taken up in a little methanol and spotted on to large sheets of filter paper together with a spot of rutin solution added as a marker.

The following results were obtained after two-way chromatography first with 10 per cent. aqueous acetic acid then with butanol 4 vol., acetic acid 1 vol., water 5 vols.

Sub- stance	Rf acetic	Rf butanol- acetic	Colour of spot under U.V.	Rutin marker	
				Rf acetic acid	Rf butanol- acetic
1	0·04	0·42	orange green/ yellow	0·37	0·48
	0·11	0·61		—	—
2	0·61	0·52	yellow	0·38	0·38
3	0·43	0·54	orange	0·40	0·45
4	0·59	0·59	yellow	0·39	0·46
5	0·36	0·72	orange	0·40	0·44

These spots correspond to those reported in last year's report (1). Thus the orange spot, the major component of substance 1 corresponds to spot A (or possibly F₁). Substances 2 and 4 which appear identical correspond to spot N, substance 3 corresponds to spot I and substance 5 corresponds to spot Q. The rutin which was

used as a marker corresponds to spot C, although this latter compound has not yet been isolated in quantity from hops.

Ultra-violet spectra kindly plotted by the Brewing Industry Research Foundation for substances 1 and 2 showed that substance 1 had a much higher absorption than substance 2, and from the wavelengths of the absorption maxima they seemed closely related.

The low Rf value of the orange component of sample 1 in 10 per cent. acetic acid indicated that this was an aglycone so that sample 2 could be a derived glycoside. However, on hydrolysis of sample 4 (insufficient of sample 2 being available) the aglycone obtained had an Rf in butanol-acetic solvent of 0.85 while the Rf of the orange spot of sample 1 in this solvent was about 0.4.

Either substances 2 and 4 are not identical or else they are not related to sample 1 in spite of the correspondence of their absorption maxima.

The hydrolysis products of the substances isolated in quantity together with those of rutin which was used as a standard are given in the table below.

Rutin (C)	Substance 3 (I) Rf Bu/Ac	Substance 4 (N) Rf Bu/Ac	Substance 5 (Q)
0.13 (rutinose)	0.07 (unknown sugar)	0.18 (glucose)	0.18 (glucose)
0.18 (glucose)	0.13 (rutinose ?)	0.39 (rhamnose)	
0.39 (rhamnose)	0.18 (glucose)		
	0.36 (rhamnose)		
0.72 (quercetin) (θ)	0.85 (unknown aglycone) (φ)	0.85 (unknown aglycone) (φ)	0.85 (unknown aglycone) (φ)

HOP RESIN ANALYSIS

Several papers have been published dealing with hop resin analysis in which the soft resins have been extracted directly with petroleum ether (2, 3, 4, 5, 6, 7). In view of the cheapness of this solvent compared with ethyl ether and the convenience of using a single volatile solvent, the Ford and Tait method was modified by substituting petroleum ether boiling below 40° C. for the initial extraction in place of ethyl ether.

Values for total soft resins were found to be about 10 per cent. lower than those obtained using ethyl ether extraction.

Extraction was then made using petroleum ether boiling range 60°-80° C. but again low values were obtained.

The possibility that loss occurred during the extraction of the total soft resins from brine emulsion was considered, and since this stage is normally required to remove the hard resins, it could, in the modified method be considered superfluous. The usual aliquot of methanolic solution was therefore pipetted directly into a tared flask, evaporated on a water bath, dried in an oven and weighed.

The following values obtained in this way were found to agree closely with those obtained by the normal Ford and Tait method and to be within the normal error of the determination.

Sample	Petrol ether boiling <40° C. extracted		Ford and Tait method (ethyl ether extracted)	
	gm. T.S.R.	gm. lead precip.	gm. T.S.R.	gm. lead precip.
A	0.195	0.265	0.201	0.300
B	0.202	0.221	0.213	0.224
C	0.220	0.232	0.228	0.236
D	0.189	0.207	0.215	0.214
E	0.206	0.225	0.220	0.234
F	0.207	0.249	0.219	0.250
Petrol ether boiling 60°-80° C. extracted				
G	0.252	0.249	0.232	0.246
H	0.183	0.222	0.182	0.219
I	0.246	0.238	0.234	0.244
J	0.246	0.228	0.230	0.226

The determinations of α -resin in the extracts obtained by both methods were also in agreement within the normal errors for this measurement, and the α -resin lead precipitates were produced more quickly and with a cleaner appearance. No explanation can be given for the apparent loss due to the extraction of soft resins from brine but if extended comparisons of the final modification with the method of Ford and Tait show agreement then the former, especially if combined with a polarimetric determination of resins, should simplify hop resin analysis considerably.

SUGAR SPRAYS

An attempt was made to introduce sugar into growing hop cones with a view to affecting the synthesis of hop resin. A marked

increase in the percentage of resin was shown in a previous experiment when a sugar solution was injected into the hop bine just below the hop cones (1). This, however, is not practicable on a large scale and if sugar solutions could be sprayed on to the growing plant and thereby introduced into the cone many more treatments could be made.

An aqueous solution containing 5 per cent. sucrose and sufficient "Teepol" to act as a wetting agent was sprayed on to individual laterals of a hop plant growing under normal field conditions until excess solution dripped off. The hop cones were then allowed to mature and when ripe they were picked and dried rapidly in an air oven at a temperature of about 50° C. The spraying was done on August 30th when the cones were about half-grown and picked on September 19th, the variety being a late one.

In addition to the spraying of sucrose solutions the possibility that a phosphorylation of the sugar would take place in the early stages of conversion within the plant was postulated. A mixed solution was therefore made containing 5 per cent. sucrose and 1 per cent. potassium dihydrogen phosphate in order to show whether the local increase in phosphate would affect the resin production. This solution was sprayed on to individual laterals as before and the mature hop cones picked and dried at a low temperature.

Untreated laterals on the same plants as were used for the previous spraying were picked, lateral by lateral, and taken as controls. Analysis for resins was carried out on a small scale using 1 gm. of material which had been dried in a vacuum desiccator.

In this particular experiment the hop selected for spraying had a low α -resin content, and probably due to the bad weather conditions during the growth of the hop cones very little lead precipitate was obtained. In fact since the precipitate in most cases did not exceed a few mg. the errors involved render these weights meaningless and they are not reported.

The total resin content of the hops treated were as follows:

Control	6.72%	Mean of 10
Sucrose + KH_2PO_4	5.63%	Mean of 5
Sucrose	6.98%	Mean of 7

The resin content of hops treated with sucrose and phosphate is significantly lower than that of the control and the sucrose treated hops at the 5 per cent. level of significance, but there is no difference between the resin contents of the sugar-sprayed hops and that of the untreated hops.

THE USE OF RADIO-ACTIVE PHOSPHORUS IN HOPS

Radio-active phosphorous ^{32}P incorporated into the molecule of certain organo-phosphorous insecticides has been used to study the systemic action of these compounds in a number of plants. Since these insecticides are of considerable importance in hop production this technique is likely to be of value in similar investigations with hops.

The cost of such radio-active insecticides is high, however, and it was decided, initially, to explore the potentialities of the technique by using the relatively cheap ^{32}P labelled orthophosphate. This compound was applied in 1956 as a fertilizer to hops growing in a range of standard soils in barrels. This series of soils comprises several soil types which for some years have been maintained at four pH levels and two nutritional levels.

The instrument used for measuring radio-activity was a portable ratemeter type 1292A, powered by dry batteries, which was hired from the U.K. Atomic Energy Authority at Harwell. The instrument, which was designed primarily for geological work, possesses a geiger tube which can be mounted on an extendable handle and used as a detecting device or alternatively it can be used in the laboratory, with a concentric plastic cup placed round the geiger tube, as an assay instrument. In the present experiment it was mainly used for assay purposes. Radio-activity was measured in both cases by readings on a micro-ammeter.

The ^{32}P was received as a solution of orthophosphate in hydrochloric acid, 10 millicuries being contained in 1 ml. of solution. This quantity was diluted with distilled water and made to 1 litre. On July 9th the active solution was poured on to the soils, each barrel receiving 50 ml. of active solution further diluted with 200 ml. of water. Allowing for a delay between receiving the active phosphate and its application this represented 0.2-0.3 millicuries per barrel. The surface area of soil was 10.5 sq. ft. and its total weight 150 lb. per barrel.

Within 24 hours of application activity could be detected in the hop leaves over the whole plant by placing the geiger tube mounted on a long handle near to the leaf. A series of rough measurements made in this way seemed to indicate that the phosphate had moved into the younger leaves at the top of the bine to a greater extent than into the older leaves at the base after 24 hours; also there appeared to be a difference between the light and the heavy soils, the uptake seeming to be much greater in the case of the heavier soils. This latter point, however, was not borne out

by more accurate measurements a week later, and it is possible that there is a very rapid redistribution of phosphate ions within a plant.

One week after the application of the radio-active solution, leaf samples were collected for analysis, selecting as far as possible the "youngest fully-formed" leaves from each bine.

An amount of leaf was taken which was judged to give about 1 gm. of dry matter per sample and was placed immediately into a weighed 100 ml. conical flask which was brought into the laboratory and oven dried at about 50° C. After cooling the flask was weighed and the dry matter weight obtained by subtraction. The dry leaf was digested in the flask with a mixture of 2 ml. concentrated sulphuric acid and 1 ml. hydrogen peroxide additional amounts of peroxide being added until a yellowish solution was obtained. All remaining organic matter was finally destroyed by heating with an addition of 1 ml. perchloric acid.

This acid digest was rinsed out with distilled water into a 100 ml. volumetric flask and made up to volume. The whole 100 ml. of solution was poured into the plastic cup of the ratemeter and with the switch on the 2 per cent. range a meter reading was taken after 15 minutes. This time allows for the meter to reach its maximum reading and can only be reduced if a greater inaccuracy due to the random nature of radio-activity can be tolerated. When a measurement of activity had been made the solution was returned to the flask. Aliquots of the solution were later taken for determinations of total phosphorus by the vanadate method.

The data tabulated below show the results obtained from two soil types:

PHOSPHORUS IN HOP LEAF SAMPLES AFTER TREATING WITH ³²P FERTILIZER
 Ratemeter reading per gm. of dry leaf corrected for background and decay.
 Total phosphorus in mg. per gm. of dry leaf.

Soil type	pH	Low nutrient status		High nutrient status	
		Ratemeter reading	Total P	Ratemeter reading	Total P
Loam ..	4.5	13	0.33	4	0.35
	5.5	12	0.31	3	0.32
	6.5	11	0.54	3	0.74
	7.5	7	0.39	2	0.64
Sandy Soil ..	4.5	10	0.42	4	0.90
	5.5	14	0.71	9	0.80
	6.5	16	0.61	2	0.76
	7.5	18	0.64	4	0.66

While the results obtained are somewhat variable, the differences relative to nutrient status of ^{32}P uptake as indicated by the ratemeter reading are quite pronounced. The hops with low nutrient status took up considerably more ^{32}P than did those with high nutrient status.

There was a pronounced variation of ^{32}P uptake with $p\text{H}$ in the loam and sandy soils, but the variation was in opposite senses. The figures representing ^{32}P uptake do not closely parallel those for total phosphorus, but this is not to be expected since the former figures relate only to uptake over a period of a week prior to sampling. The experience gained from this experiment showed that although measurements of activity could be made using about 1 gm. of leaf with the level of ^{32}P applied, the instrument was relatively insensitive on account of the thickness of the plastic container and glass envelope of the geiger tube which absorbed much of the radiation emitted. A counting instrument together with a geiger tube immersed directly in the liquid should prove much more sensitive.

RESIN ANALYSES

Resin analyses have been carried out on the 1956 crop on behalf of other organizations as well as for current research within the Department.

These have been as follows:

Institute of Brewing Challenge Cups	58
Comparison of hand picking and machine picking ..	64
Samples from Rosemaund Experimental Farm ..	79
Hop Department Plant Breeding Trials	169
" " Cultural and Manurial Trials ..	53
Miscellaneous	49
Total ..	472

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PLANT PATHOLOGY SECTION

REVIEW OF THE YEAR'S WORK

H. S. DARLING and DOROTHY M. DERBYSHIRE

(a) SYSTEMIC INSECTICIDES AND CONTROL OF THE HOP APHIS

In 1956, the first winged adults of the hop aphid, *Phorodon humuli* Schr., invaded the hop crop at Wye in the last week of May. The main invasion began about June 1st, being nearly two weeks earlier than in 1955 and being sooner than was expected in view of the general lateness of the season.

Winged adults continued to invade the crop during June and July, and on July 28th large numbers of such aphids were seen on young foliage in hop propagation rows. Scattered winged adults, presumably immigrants, were still to be found on young leaves as late as August 4th. The attack by this pest appeared to be heavier in 1956 than in the previous two years. No attack by the hop red spider, *Tetranychus urticae* Koch, was observed.

Three systemic insecticides were used for aphid control on a field scale, each being applied to an area of at least three acres. Their use presumably contributed to the freedom from red spider attack referred to above. These insecticides were:

schradan	(bis dimethylaminophosphonous anhydride)
"Metasystox"	(bis ethylthioethyl dimethylphosphorothionate)
dimefox	(bis dimethylamino fluorophosphine oxide)

Of these, the first two were used as sprays, while dimefox was applied as a soil insecticide only.

Schradan

This compound was applied as a high volume spray at the standard recommended rate of 7-8 fluid ounces of the commercially pure active ingredient in 100 gallons of water, giving a spray concentration of about 0.05 per cent.

Three applications were made during June and July resulting in moderately good aphid control. This systemic insecticide did not appear to be as effective as in the two previous years. The protection afforded by the initial application made in the first half of June lasted for less than 14 days compared with 20-25 days

in past seasons. It is possible that the wet cold weather which occurred in June reduced the efficiency of this spray by partially preventing the absorption of the insecticide by the plants and by impeding its subsequent translocation to new growth made after the date of spraying. Better results were recorded for the two later applications which were made under warmer conditions.

"Metasystox"

This compound was applied three times as a high volume spray during June and July at the standard recommended rates of 6 fluid ounces (170 grammes) of the commercially pure active ingredient per acre for the first spray, and twice this amount for subsequent sprayings.

This insecticide, though less strikingly effective than in 1955, gave good control. Its contact effect killed all aphids on the plants at the time of spraying and its systemic effect gave protection against re-invasion for up to three weeks. Under the unfavourable conditions of the 1956 summer "*Metasystox*" appeared to be more effective than schradan.

Dimefox

A single field scale application of this compound was made to Golding hops in the first half of June, at the standard recommended rate of about 0.5 grammes of commercially pure active ingredient in 4 fluid ounces (114 ml.) of water per hill.

This single application after a slow start gave good control for nearly six weeks. Thereafter aphid populations increased rapidly until eliminated by a "*Metasystox*" spray in late July. As with the other two insecticides discussed above, dimefox appeared to be less effective in 1956 than in 1955 when a single application of the standard rate gave good control for about two months.

On pages 24 and 46 of the Departmental Report for 1955, reference was made to the fact that dimefox killed cuttings of a number of unnamed seedlings when applied to propagation rows in the plant breeding nursery at Wye. In 1956 an investigation was carried out on the effect of dimefox on mature hills of some of the seedlings which had proved to be susceptible as cuttings. It was found that, as described on p. 18, the standard recommended dose caused very severe symptoms. These ranged from extensive damage to leaves and growing points to complete death of the hill.

Comparative tests were made with liquid and experimental pellet formulations of dimefox applied to mature hills of Eastwell Golding. The results obtained confirmed the findings of similar tests in 1955 (Darling and Derbyshire, 1956) by showing pellets to be slower acting than the liquid treatments. The latter were fully effective in less than a week while the former required 10 to 19 days to establish their maximum control.

As in 1955 it was found that pellets had a longer effective life in the soil than liquid formulations and therefore gave more efficient control for a given dosage of dimefox. Thus 0.3 grammes per hill applied as pellets gave good control for the same period as 0.5 grammes applied as a liquid. In liquid treatments at dosages of 0.3, 0.4 and 0.5 grammes per hill of dimefox, the approximate periods of effective control, i.e., during which less than 30 per cent. of the leaves showed resident aphids, were respectively 35 days, 38 days and 41 days.

With pellets there was a greater risk than with liquid formulations of some bines failing to take up the insecticide, especially at lower levels of dosage. In the liquid treatments at the dosages described above all bines received dimefox. In a pellet treatment at 0.1 grammes per hill 10 per cent. of the bines failed to take up the insecticide. With pellets at 0.3 grammes per hill the percentage of bines which failed to take up the insecticide was only 0.5 per cent.

The pellet treatment at 0.3 grammes dimefox per hill was divided into two sub-treatments. In the first the whole dose was applied at a single point on the crown of the hill, the pellets being placed against the hill tissue in a hole scooped in the earth for the purpose and then covered over with 1 to 2 inches of soil. In the second sub-treatment the dose was similarly applied except that it was dispersed as three 0.1 gramme pellets placed one at each of three separate points over the crown of each hill. It was found that while the degree of control finally achieved was very similar in both sub-treatments, the dispersing of the dose over the crown of the hill gave more satisfactory performance in that the insecticide took effect more rapidly, and none of the bines failed to take up the insecticide.

Dimefox residues in dried hops

Duplicate series of samples of hop cones from the dimefox treatments were picked and dried separately on September 11th, about 13-14 weeks after the insecticide was applied. The resulting hops were pressed into box samples which were wrapped in paper

and polythene film and kept in a refrigerator for 6 months at 38° F. to simulate cold storage in a brewery hop store.

The two series of samples were then analysed for dimefox residues, one being examined by the Department of the Government Chemist and the other by Mr. E. D. Chilwell of Messrs. Fisons Pest Control, Ltd. The results of these analyses agreed in showing that the residues were small, not exceeding 0.20 parts per million by weight.

In general the results differed from those obtained in 1955 by Mr. Chilwell (Darling and Derbyshire, *loc. cit.*) in that the 1956 residues were smaller, especially in the pellet treatments where the values were no greater than in the liquid treatments. The smaller size of the residues may have been due in part to the wetter summer of 1956 which presumably reduced the concentration of dimefox in the soil, and also to the longer period for which the 1956 samples were stored before analysis.

General

All three systemic insecticides discussed above were less effective in 1956 than in 1955. This was probably due in large measure to the unfavourable season and to the heavy aphid attack. The prevailing low temperatures interfered with plant growth and probably hindered the translocation of systemic material in the sap. The successive waves of aphid invasions during June and July maintained immigrant populations at relatively high levels making it possible for the pest to exploit any local failures in systemic control. The possibility must be considered, however, that strains of the hop aphid may be appearing which are in some degree resistant to these organo-phosphorous compounds.

The weather in the first half of June, when aphid control was essential, was wet and stormy. Under these conditions it was found that soil application of dimefox was the most efficient treatment, being unaffected by rain or high winds. Of the two spray treatments, the application of "Metasystox" was less affected by bad weather than schradan. Provided the former was followed by a few hours without rain good results were obtained. With the latter, however, any noticeable rainfall within 24 hours of application reduced the effectiveness of the spray.

(b) SPRAYING TRIALS ON THE CONTROL OF HOP DOWNY MILDEW (*Pseudoperonospora humuli*)

The replicated spraying trial on the control of Downy Mildew carried out in 1955 (Darling and Derbyshire, *loc. cit.*) was repeated

in 1956 using the variety Petham Golding only. The lay-out, management, and high volume spraying technique were the same as in 1955, as were the three spraying treatments namely:

Bordeaux mixture: 10 lb. copper sulphate crystals and 15 lb. lime in 100 gallons water.

Copper oxychloride: 3 lb. commercial formulation in 100 gallons water.

Captan: $2\frac{1}{2}$ lb. wettable powder (50 per cent. active ingredient) in 100 gallons of water.

The trials commenced on July 1st, 1956, prior to which all plots were treated with the soil-applied systemic insecticide dimefox on June 13th and with captan sprays on June 20th and 26th.

The experimental sprays were applied five times during July and August as follows:

July 4th	at 200 gallons per acre
July 16th	at 350 gallons per acre
July 24th	at 400 gallons per acre
August 8th	at 300 gallons per acre
August 23rd	at 300 gallons per acre

The cold dry spring and the cool wet summer gave unsuitable conditions for the crop which made relatively light growth. This unfavourable seasonal trend was greatly accentuated by the gale on July 29th (see p. 14) which caused severe damage to the young growth, particularly the fruiting laterals.

Downy Mildew appeared in April in the form of many basal spikes. In spite of the routine removal of infected tissue the attack persisted and in June and July the incidence of lateral and terminal spikes was very severe. The removal of infected shoots appreciably reduced aerial growth and so added to the unfavourable effect of the weather. The incidence of spikes was much less in August which may have been due either to decrease in natural infection, or to the destruction of much of the young and susceptible tissue by the gale on July 29th.

The numbers of spikes recorded during July for the 60 hills in each treatment are given below:

Treatment	Date of Recording		Total No. of Spikes
	19th July	27th July	
Bordeaux mixture ..	85	44	129
Copper oxychloride ..	161	48	209
Captan	94	45	139

Owing to the great variation in the incidence of spikes within each treatment no definite conclusion can be drawn from these data. They suggest, however, that as in 1955 captan was as effective as the copper fungicides in controlling the spike form of the disease. It will be noticed that the recorded incidence of spikes in July, 1956, was about twice as great as that recorded in July and August, 1955.

Some evidence of Downy Mildew infection was observed in the garden until the end of the season and a final spray was given on August 23rd to protect the developing crop. Careful examination at picking time showed that the cones in all treatments were equally free from the disease. The captan-treated cones before drying appeared to be rather brighter and more attractive in appearance than those from the copper treatments.

The plots were picked on September 13th. Yield data are tabulated below:

Treatment	Green Bushels per acre	Cwt. Dried Hops per acre	Green Bushels per dried cwt.
Bordeaux mixture	556	4.9	113
Copper oxychloride	625	5.4	117
Captan	633	5.4	118

Yields were about a quarter of those recorded in 1955, the reduction being due mainly to gale damage. Because of the very low level of yield the data must be regarded as of little or no value for assessing the effects of the treatments.

Samples of cones from the three treatments gave the following values for resin content:

Treatment	Total Soft Resin %	α -resin %
Bordeaux mixture ..	12.12	4.76
Copper oxychloride ..	12.29	5.00
Captan	12.41	4.89

These resin values are all within the expected range of variation for Golding hops.

Examination of the dried hops by a hop factor revealed that none were of grade one quality owing to wind damage and the

general effect of the poor season. Little or no difference could be found between the samples.

Dry-hopping trials were carried out by the Brewing Industry Research Foundation with hops which had received their last spray on August 23rd. These trials showed that captan-treated hops caused a slight but definite off-flavour in the beer.

Dry-hopping trials were also carried out by the B.I.R.F. with hops which had been sprayed with captan on September 8th, only five days before picking and presumably were heavily contaminated with the fungicide. These hops caused a strong sulphur taint in the beer.

These trials indicate that captan must not be used to protect ripening hop cones which are intended for dry-hopping. This finding is of special importance in the case of Goldings which are often used for this purpose. Such hops should not be sprayed with captan after the middle of August.

While the 1955 brewing trials described in last year's report have shown that captan-contaminated hops cause no tainting in beer when used in the copper, the recent dry-hopping trials suggest strongly that the general application of this fungicide to ripening hops is not to be recommended.

(c) TESTING FOR RESISTANCE TO DOWNY MILDEW

In the Annual Report for 1954, mention was made of breeding hops resistant to Downy Mildew (Neve and Farrar, 1955). Preliminary work has been carried out during this season on methods of testing plants for resistance to this disease.

A detached leaf technique was used to obtain a comparative scale for the extent of infection of leaves of different varieties. As a high humidity is necessary both for inoculation and the production of sporangia, the leaves were placed in petri dishes lined with moistened filter paper. From each plant, leaves at four stages of development were chosen. A suspension of sporangia in tap water was allowed to stand until the motile zoospores were liberated from the sporangia. The lower surfaces of the leaves were then sprayed with this suspension, using an atomizer. After incubation for a suitable time at room temperature, the leaves were examined for sporangiophores bearing sporangia. It was found necessary to assess the susceptibility of both young and old leaves, and to take into account the density of sporangiophores produced on the lesions. Leaves of plants received from Dr. Zattler at Munich, and seedlings raised from these female parents by open pollination

at Wye were compared with leaves of certain commercial varieties.

Leaves from Dr. Zattler's plants showed a high degree of resistance to the fungus. One seedling family of 15 plants, obtained from Zattler 7K.491, gave two plants showing marked leaf resistance and, in comparison with Golding material, seven plants of intermediate resistance. In another family of eight plants from Zattler 2L.118, there were two showing marked leaf resistance and two of intermediate resistance. None of the seedlings in these two families was as resistant as its female parent.

Some rooted lateral cuttings of seedlings and commercial varieties, taken in July, produced cones which were inoculated with a suspension of zoospores. After incubation in a moist atmosphere, sporangiophores developed on cones of susceptible varieties and sufficient difference in the extent of infection was shown, for the method to be considered in the selection of plants in the breeding programme.

(d) MAINTENANCE OF A SUPPLY OF INOCULUM DURING THE WINTER

A stock of growing plants has been maintained throughout the winter in a heated glasshouse equipped with artificial lighting (see p. 73).

Detached young leaves were inoculated in the laboratory at regular intervals, by the method described above. It was found essential to keep the shoots growing vigorously and producing a succession of young leaves, as old leaves from the glasshouse, including those of susceptible varieties, did not become infected.

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THE EFFECT OF MACHINE PICKING ON THE RESIN CONTENT OF HOPS—1956 CROP

H. S. DARLING and F. C. THOMPSON

SUMMARY

A survey was carried out of 25 pairs of pocket samples from the 1956 English hop crop. Each pair consisted of one hand-picked and one machine-picked sample from the same growth of the same variety picked on the same farm at approximately the same stage of ripeness.

The machine-picked samples had significantly less resin than the hand-picked ones, the average loss being 1.41 per cent. total soft resins. This was nearly twice as great as the losses recorded in 1954 and 1955. The leaf and stem content was significantly greater by 1.5 per cent. in the machine-picked samples, and this fraction was larger in both hand- and machine-picked hops in 1956 than in 1954 or 1955. Physical examination failed to reveal any visible differences between hand- and machine-picked samples other than in respect of the leaf and stem fractions.

The data available suggest that in 1956 much of the resin loss associated with machine-picking was due to loss from whole and apparently undamaged cones; increased dilution of the sample with leaf and stem was also a contributory factor. These results agree with the findings of the earlier surveys.

INTRODUCTION

A survey, similar to those carried out in 1954 and 1955 and described in last year's report (Darling and Thompson, 1956), was made in respect of the 1956 crop using 25 pairs of pocket samples as follows:

Fuggles	11 pairs
Goldings	8 pairs
Golding Varieties	4 pairs (including one pair of Whitbread's G.V.)
Keyworth's Midseason	2 pairs

Each pair of samples consisted of one machine-picked and one hand-picked sample from the same growth of the same variety, picked on the same farm at approximately the same stage of ripeness. Of the 25 pairs of samples, 19 were provided through the kindness of registered growers and collected by the Hops Marketing Board. The remaining six pairs were kindly provided by the Guinness Hop Farms, Ltd. Three of the 25 pairs came from the West Midlands and 22 came from the South-East.

The methods and techniques used were the same as described in last year's report.

RESULTS.

The detailed results are given in Table 1.

(a) *The effect of machine picking on resin content*

The total soft resins content of the pocket samples averaged 10.97 per cent. for the hand-picked and 9.56 per cent. for the machine-picked hops. The decrease in resin content of 1.41 per cent. associated with machine picking was statistically significant.

In 22 of the 25 pairs of pocket samples there was more resin in the hand-picked hops; in the remaining three pairs the reverse was the case. In the hand-picked samples the resin content varied from 8.36 per cent. to 13.30 per cent.; in the machine picked samples it varied from 7.50 per cent. to 11.54 per cent.

The average values for total soft resins content for the fractions provided by physical analysis were as follows:

	<i>Hand-picked</i> T.S.R. per cent.	<i>Machine-picked</i> T.S.R. per cent.
Whole hop	13.55	12.95
Broken hop	10.80	10.95
Petal and seed ..	9.88	9.84
Leaf and stem ..	1.43	1.87

In the whole hop fractions the hand-picked hops had 0.60 per cent. more resin than their machine-picked counterparts, the difference being statistically significant. In 19 out of the 25 pairs the hand-picked whole hops were richer in resin; the reverse was the case in the remaining six pairs. Values ranged from 11.67 per cent. to 15.98 per cent. in the hand-picked and from 10.96 per cent. to 15.27 per cent. in the machine-picked whole hops.

In the broken hop, petal and seed, and leaf and stem fractions, the results given above derive from only two pairs of bulk samples in each case and no statistical treatment of the data was possible. It will be noted that no resin loss due to machine-picking was apparent in these fractions, and that there was a measurable amount of resin associated with the leaf and stem fractions. The latter was presumably due to the addition of resin incurred during the processing of the crop.

TABLE I
DETAILED RESULTS OF 1956 SURVEY OF HAND-PICKED AND MACHINE-PICKED HOPS

Grower and Locality	Sample Pair Numbers	Hop Variety	Hand-picked Samples					Machine-picked Samples						
			Whole Hop %	Broken Hop %	Petal and Seed %	Leaf and Stem %	T.S.R. cones only %	T.S.R. original sample %	Whole Hop %	Broken Hop %	Petal and Seed %	Leaf and Stem %	T.S.R. cones only %	T.S.R. original sample %
Mr. "A" (S.E.)	1 and 101	Golding	24.5	20.5	47.5	7.5	13.30	8.44	63.6	26.6	5.7	4.1	15.00	11.54
	2 and 102	"	39.5	22.7	31.5	6.3	13.96	9.59	43.5	20.7	27.4	8.4	14.24	9.67
	3 and 103	Golding Variety	41.9	18.2	35.1	4.8	13.40	8.54	39.6	18.3	34.0	8.1	11.81	8.11
	4 and 104	Golding	20.5	29.5	29.5	9.7	12.54	9.99	44.1	18.1	23.1	14.7	12.59	9.38
	5 and 105	"	37.0	19.3	35.0	8.7	12.96	8.36	32.2	22.9	38.0	6.9	12.40	8.97
Mr. "B" (S.E.)	6 and 106	Golding Variety	36.7	27.1	30.0	5.3	12.22	10.40	36.9	20.3	36.9	5.9	11.90	8.88
	7 and 107	Fuggle	52.4	20.9	22.3	4.4	13.23	11.19	27.1	28.3	39.3	5.3	11.74	9.24
Mr. "C" (S.E.)	8 and 108	Fuggle	53.8	15.6	25.1	5.5	13.63	10.99	30.4	20.5	41.8	7.3	11.53	8.09
	9 and 109	"	39.5	21.0	31.8	7.7	13.10	10.37	56.9	15.4	21.8	5.9	10.96	8.66
Mr. "D" (S.E.)	10 and 110	Fuggle	26.5	28.4	40.6	4.5	12.87	10.74	33.2	19.5	40.1	7.2	12.80	9.94
Mr. "E" (W.M.)	11 and 111	Fuggle	55.5	26.6	14.5	3.4	13.15	11.74	45.2	26.8	20.3	7.7	12.93	9.93
Mr. "F" (W.M.)	13 and 113	Fuggle	37.1	21.2	36.8	4.9	14.09	11.51	27.4	27.7	38.0	6.9	13.01	7.50
	14 and 114	"	26.8	21.4	46.9	4.9	12.17	11.00	31.7	22.0	41.3	5.0	13.36	8.91
Mr. "G" (S.E.)	15 and 115	Golding	34.2	20.4	41.3	4.1	14.19	12.66	45.4	18.2	27.3	9.1	12.58	10.08
	16 and 116	"	45.0	20.4	27.5	7.1	14.86	11.91	34.0	19.2	34.8	12.0	13.94	8.73
Mr. "H" (S.E.)	17 and 117	Whitbread's Golding Variety	54.3	26.9	13.4	5.4	12.69	10.21	38.2	20.1	31.8	9.9	12.00	9.97
Mr. "I" (S.E.)	18 and 118	Golding	34.7	27.7	35.4	2.2	15.17	12.20	42.8	23.3	26.9	7.0	14.71	10.47
	19 and 119	"	38.7	23.2	34.9	3.2	14.44	12.05	27.4	23.4	43.4	5.8	12.71	8.97
	20 and 120	Golding Variety	40.3	24.6	31.9	3.2	12.84	10.59	52.5	24.0	19.1	4.4	11.97	10.45
Mr. "J" (S.E.)	21 and 121	Keyworth's Midseason	46.1	25.8	24.0	4.1	15.98	12.08	43.2	30.5	22.6	3.7	15.27	10.95
	22 and 122	"	44.2	21.2	30.0	4.6	15.95	13.30	34.0	17.1	21.3	7.6	12.60	10.53
	23 and 123	Fuggle	35.0	22.2	37.9	4.9	13.40	11.68	32.0	24.3	38.8	5.0	14.73	9.70
	24 and 124	"	22.3	23.4	19.7	4.6	11.67	11.55	42.0	23.8	28.2	6.0	14.03	9.88
	25 and 125	"	40.3	24.4	29.5	5.8	13.03	11.06	22.1	20.4	54.7	2.8	12.05	10.40
	26 and 126	"	38.4	20.8	34.6	6.2	13.92	12.12	26.0	24.1	37.8	5.5	12.91	9.95

S.E. = South-East England.

W.M. = West Midlands.

(b) *The effect of machine picking as shown by physical analysis*

Physical analysis gave the following average figures for the 25 pairs of samples:

	<i>Hand-picked</i> per cent.	<i>Machine-picked</i> per cent.
Whole hop	39.4	38.9
Broken hop	22.6	22.3
Petal and seed ..	32.7	32.0
Leaf and stem ..	5.3	6.8

The average leaf and stem content of the machine-picked samples was 6.8 per cent., being 1.5 per cent. more than the 5.3 per cent. recorded for the hand-picked samples. This increase in leaf and stem content associated with machine picking was statistically significant. The values for this fraction ranged from 2.2 per cent. to 9.7 per cent. in the hand-picked, and from 2.8 per cent. to 14.7 per cent. in the machine-picked samples. In 19 of the 25 pairs of samples the machine-picked hops had more leaf and stem; in the remaining six pairs the hand-picked hops had the higher values.

The average values for the other fractions were very similar and examination showed that no consistent physical differences could be distinguished in respect of these fractions between hand- and machine-picked samples.

(c) *Varietal response to the effects of machine picking*

The results of the survey in terms of varieties are summarized in Table 2, in which the categories "Whole hop" and "Broken hop" have been combined under the heading "Recognizable hop", and the heading "Resin" refers to the values for total soft resins obtained from the original pocket samples.

The data in Table 2 suggest that the Goldings and Keyworth's Midseason are less broken by machine picking than Fuggles and the Golding varieties, a suggestion which conforms to general commercial experience. They also support the findings of earlier surveys that the resin loss associated with machine picking is not obviously related to the amount of cone breakage incurred. Thus the resin loss in machine-picked Keyworth's Midseason was of the same order as that observed in machine-picked Fuggles although the amounts of cone breakage (as indicated by the size of the "Petal and seed" fraction) were very different.

TABLE 2

VARIETAL RESPONSE TO HAND AND MACHINE PICKING IN 1956

Variety	Nos. of pairs of Samples	Hand-picked				Machine-picked			
		Recognizable Hop %	Petal and Seed %	Leaf and Stem %	Resin %	Recognizable Hop %	Petal and Seed %	Leaf and Stem %	Resin %
Fuggle ..	11	61.2	33.6	5.2	11.27	57.2	37.1	5.7	9.22
Goldings ..	8	58.6	35.3	6.1	10.64	63.2	28.3	8.5	9.65
Golding Varieties ..	4	67.5	27.8	4.7	9.94	62.5	30.4	7.1	9.35
Keyworth's Midseason (OR55) ..	2	68.6	27.0	4.4	12.69	72.4	21.9	5.7	10.74

DISCUSSION OF RESULTS

The 1956 season produced a light crop which in some areas was much affected by wind and storm damage. Hop production throughout the country was well below quota and the consequent pressure on growers to reduce wastage to a minimum may partially account for the high leaf and stem values recorded in 1956 in both hand- and machine-picked samples. Such contamination was much higher than was observed in the 1954 and 1955 surveys as is shown below:

	<i>Leaf and stem content per cent.</i>	
	<i>Hand-picked samples</i>	<i>Machine-picked samples</i>
1954	4.1	5.1
1955	2.8	3.5
1956	5.3	6.8

The high leaf and stem content may also have been due in part to wind and storm damage which left the foliage in such a tattered condition that it broke up easily during picking. In storm-affected areas it was very difficult to obtain a clean sample. Such storm damage was especially severe in East Kent in which the majority of the Golding samples were produced, and Table 2 shows that the leaf and stem content of these samples was very high, being greater than in any of the other varieties. This is at variance with the findings of the 1954 and 1955 surveys, which showed the leaf and stem content of Goldings to be lower than in other varieties. Presumably the 1956 values reflect the incidence of gale damage.

The 1956 resin loss associated with machine picking, as measured in the pocket samples, averaged 1.41 per cent. This is nearly twice as great as the corresponding losses of 0.75 and 0.79 per cent. recorded in 1954 and 1955 respectively. In the case of the 1956 deficit, 0.6 per cent. can be accounted for by resin loss from apparently whole and undamaged cones; the corresponding values for 1954 and 1955 were 0.51 and 0.97 per cent. respectively. A further 0.20 per cent. can be attributed to the increased dilution of the machine-picked samples with leaf and stem. The balance of 0.61 per cent. cannot be accounted for in terms of the data provided by the survey. Such a discrepancy is not surprising in view of the relatively small number of samples involved, and of the very variable nature of the material produced by such an unfavourable season.

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A NOTE ON A SAND CULTURE EXPERIMENT ON THE NICKEL NUTRITION OF THE HOP PLANT IN RELATION TO THE INCIDENCE OF NETTLEHEAD DISEASE

F. C. THOMPSON

SUMMARY

A preliminary survey carried out by the Brewing Industry Research Foundation in 1955 suggested that Nettlehead in hops might be due to high concentrations of nickel in the plants. A sand culture experiment was carried out at Wye in 1956 to investigate this possibility.

It was found that applications of nickel sulphate in nutrient solution to Fuggle N hops grown in sand culture, increased the nickel content of the plants as shown by leaf analysis. This increased nickel content did not result in the development of Nettlehead, however, the main symptoms recorded being a chlorosis and scorch of the leaves, typical of a mineral toxicity effect.

A description is given of the standard nutrient solutions used at Wye for the growth of hops in sand culture.

INTRODUCTION

Nettlehead is one of the most important economic diseases of hops. It was first shown to be graft-transmissible by Ware (1939) and his findings were subsequently confirmed by Keyworth and Davies (1946); in consequence, Nettlehead is considered to be a virus disease, though no natural vector has as yet been discovered. The incidence of Nettlehead is known to be related to environmental conditions and, in particular, to be prevalent on the sites of cleared hedgerows and in hop gardens planted after old pasture (Keyworth and Hitchcock, 1948).

Recently, in 1955, Hudson (1956), at the Brewing Industry Research Foundation, analysed samples of soil and plant material taken from Nettlehead infected areas and compared the results with those from samples taken from healthy areas in the same garden. He found that samples from diseased hills contained more nickel than those from healthy hills and he suggested that high levels of nickel might make the plant more prone to attack by Nettlehead. In view of Hudson's findings, staff of the Plant

Pathology Section at East Malling Research Station, who are carrying out intensive research on Nettlehead, decided to investigate, in 1956, the possibility of a relationship between the disease and the nickel nutrition of the hop plant. Hudson also continued his investigations, in this year, in consultation with the staffs of East Malling and Wye College. The findings of this work will be published elsewhere by the workers concerned, but it may be said that they do not support the possibility that high nickel content is the cause of Nettlehead. Complementary to the East Malling investigations, it was agreed that a small sand culture experiment should be carried out at Wye in 1956, using hops of the variety Fuggle N in contrast to the variety Early Prolific which was to be used at East Malling.

EXPERIMENTAL

Twelve Fuggle N plants were established in washed Bedfordshire sand in 12 inch pots. The plants were grown from cuttings, with the standard Wye major and trace element solutions, details of which are given below:

<i>Major Element Stock Solutions</i>			<i>Trace Element Stock Solution</i>	
		gms.		gms.
Solution A	A.R. KNO_3	40	A.R. $\text{MnSO}_4 \cdot 4\text{H}_2\text{O}$	0.120
	A.R. NaNO_3	100	A.R. H_3BO_3	0.170
	A.R. $\text{NaH}_2\text{PO}_4 \cdot 2\text{H}_2\text{O}$	15	A.R. $\text{ZnSO}_4 \cdot 7\text{H}_2\text{O}$	0.022
Solution B	A.R. $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$	30	A.R. $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$	0.020
	A.R. $\text{CaCl}_2 \cdot 6\text{H}_2\text{O}$	60	A.R. $(\text{NH}_4)_6\text{Mo}_7\text{O}_{24} \cdot 4\text{H}_2\text{O}$	0.004
			Pure $\text{FeC}_6\text{H}_5\text{O}_7 \cdot 3\text{H}_2\text{O}$	3.200

Each stock solution is made up in 2.5 litres of distilled water. In preparing the major element stock solutions it is found necessary to keep the calcium in a separate solution, to avoid precipitation of calcium phosphate.

APPLICATION OF NUTRIENT SOLUTIONS

The routine procedure adopted was to apply 500 ml. of the diluted major element solution (17 ml. of each of the stock solutions A and B above made up to 500 ml. with distilled water) on three occasions in each week; it was convenient to do this on Monday, Wednesday and Friday. In addition, a 500 ml. application of diluted trace element solution (12.5 ml. of the stock solution made up to 500 ml. with distilled water) was given once per week – Saturday.

The nutrient concentrations applied to the plants in these diluted solutions, were as follows:

<i>Major elements</i>	<i>p.p.m.</i>	<i>Trace elements</i>	<i>p.p.m.</i>
Potassium	210 K	Manganese	0.3 Mn
Nitrogen	299 N	Boron	0.3 B
Phosphorus	41 P	Zinc	0.05 Zn
Magnesium	40 Mg	Copper	0.05 Cu
Calcium	150 Ca	Molybdenum	0.02 Mo
		Iron	6.0 Fe

The plants were watered, as required, with 500 ml. quantities of distilled water, on the days when nutrient solutions were *not* given. As the pots were kept outside they were subject to leaching by rain, but in addition, under dry conditions, they were leached once every three weeks with distilled water (1 litre per pot) to remove accumulated salts.

DESIGN OF EXPERIMENT AND NICKEL TREATMENTS

Four levels of nickel were applied as nickel sulphate (A.R. $\text{NiSO}_4 \cdot 7\text{H}_2\text{O}$), replicated three times in a randomized block lay-out, viz. nil, 0.5 p.p.m., 1.0 p.p.m. and 2.0 p.p.m. Ni. The nickel treatments were commenced on July 2nd, 1956, when the plants had become established and were making satisfactory growth. Applications were made three times per week, giving 500 ml. per pot on each occasion.

VISUAL OBSERVATIONS

By July 14th there was an indication of toxicity symptoms appearing in the high nickel treatments—mainly a chlorosis of the younger leaves with occasional leaves showing a slight marginal and tip-scorching. These symptoms developed further during the next two weeks, but at the end of the four-week period no plants showed symptoms resembling Nettlehead.

At the end of four weeks the 0.5 p.p.m. Ni treatment was raised to 5.0 p.p.m. Ni, to try to induce more severe nickel toxicity symptoms than had appeared up to then. At the end of six weeks the most severe toxicity symptoms were still showing on those plants receiving 2.0 p.p.m. Ni, though more marked symptoms were beginning to show on the plants now receiving 5.0 p.p.m. Ni. The plant showing the poorest growth was No. 10 (high nickel), which was stunted with the leaves distorted and chlorotic. Samples of the "youngest fully formed" leaves were taken on August 14th, and sent for analysis to Mr. A. C. Mason at East Malling Research Station.

The results obtained were:

Plant No.	Treatment	Ni p.p.m. in d.m.
1	Low nickel (0.5+5.0 p.p.m.)	—
2	Nil nickel	—
3	Medium nickel (1.0 p.p.m.)	16.0
4	High nickel (2.0 p.p.m.)	25.0
5	Nil	<9.0
6	Low	29.0
7	Medium	14.0
8	High	30.0
9	Medium	16.0
10	High	30.0
11	Low	20.0
12	Nil	<9.0

The results for plants Nos. 1 and 2 are not given since there was some confusion about the labelling of these samples. The remaining figures, however, show that the nickel contents of the plants increased, as expected, in relation to the applications of nickel. It will be noted that the "low" treatment, where the rate of application was raised from 0.5 to 5.0 p.p.m. Ni, shows higher values for nickel than the medium treatment.

The experiment was concluded on September 4th, by which time the plants had been receiving nickel for ten weeks. At this time the plants generally were showing fair to good growth with the exception of plant No. 10 (high nickel) and plant No. 6 (low nickel), both of which were very stunted in growth.

CONCLUSION

Applications of nickel sulphate to Fuggle N Hops, grown in sand culture, increased the nickel content of the plants as shown by leaf analysis. This increased nickel content did not result in the development of Nettlehead symptoms, however, the main symptoms recorded being a chlorosis and scorch of the leaves, typical of a mineral toxicity effect, at the high nickel concentrations.

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THE INCIDENCE OF DOWNY MILDEW (*PSEUDOPERONOSPORA HUMULI*) IN NEW SEEDLING VARIETIES OF HOPS AT WYE

F. H. BEARD

SUMMARY

An account is given of the incidence of Downy Mildew at Wye during the seven year period 1950-1956 in 77 new seedling varieties of hops bred by Professor Salmon and grown in Wye Field hop garden. The various forms of the disease are described and appropriate control measures are outlined. The effect of summer rainfall is discussed and it is concluded that this factor alone does not play a consistent part in the spread of the disease.

A great range in varietal susceptibility to Downy Mildew has been observed. In the most resistant seedling, CC77, the incidence of diseased shoots (spikes) of all types has averaged only 4 per year per 100 hills. In the most susceptible seedling, Wye Field Golding, the corresponding number is 1,518 per 100 hills. As in earlier work, no relationship has been found between susceptibility to the spike form of the disease and to attack in the rootstock.

The 77 varieties recorded include derivatives of Wild Hop, Manitoba, of New Mexican Wild Hop and Oregon Cluster. In each case the descendants have shown a wide range of susceptibility to the spike form of the disease and no consistent trends have emerged. With regard to rootstock infection, derivatives of Wild Hop, Manitoba, and Oregon Cluster were relatively susceptible, while descendants of New Mexican Wild Hop were markedly resistant.

INTRODUCTION

During the past fifty years Professor Salmon has raised a very large number of new seedling hops, mainly of hybrid origin. The more promising of the seedlings have been planted out in large plots so as to give an indication of cropping capacity and to provide material for market and brewing evaluation; in addition records have been taken of the incidence of Downy Mildew (*Pseudoperonospora humuli*). Until 1950 the bulk of this testing was done at East Malling Research Station and an account of the incidence of the disease from its first appearance at East Malling in 1924 until 1936 has been published (Beard, 1937).

Since 1950 the testing of the seedlings has been carried out at Wye in the Wye Field hop garden and recently a summary of

the results obtained at East Malling and Wye from 33 varieties now growing in Wye Field was published (Beard and Salmon, 1955). The present paper deals with the behaviour of 77 varieties, including the 33 referred to above, during the period 1950-56. As there is a constant change of plant in the experimental garden, due to unsatisfactory seedlings being grubbed and replaced by new ones, most of the varieties dealt with in this paper were not in cultivation at the time of the 1937 report. Further, the records taken on the Wye Field plots are more detailed than those taken at East Malling, where only the number of hills producing spikes was noted; at Wye, however, the number of spikes produced by each plant was recorded at each inspection of the garden. In the 1937 report particular attention was paid to the behaviour of the various parentage groups and only the more important seedlings were dealt with individually. In the present report more information is given regarding the individual varieties as well as behaviour of a parentage group as a whole.

The Wye Field garden is planted at 6 ft. square with 12 ft. 9 in wirework, and the vines are trained on the "upright umbrella" system. For the more vigorous varieties both spacing and height of wirework are inadequate and tend to produce tangled growth with consequent greater risk of late attacks of Downy Mildew.

FORMS OF ATTACK BY DOWNY MILDEW

Before considering the data it seems desirable to discuss briefly the various forms in which the disease manifests itself and the present-day control measures for each type of infection.

Basal Spikes

When growth starts in the spring, affected buds fail to develop normally and produce typical stunted shoots of a yellowish colour, known as "basal spikes". If these spikes are not removed promptly, large numbers of spores, by which the disease is spread, may be produced on the under surfaces of their leaves. Under good cultural conditions gardens are regularly inspected and the spikes removed, in most seasons a weekly inspection being necessary. After the strings are furnished and the surplus vine removed there are fewer basal spikes, but some continue to be produced until new basal growth is suppressed by the earthing-up of the hills during June. In a newly planted garden basal spikes may be rare for the first few seasons (Beard, 1952; and p. 65 of this report), but in later years,

though there may be seasonal variation, there are always substantial numbers except in the case of varieties with marked resistance to the disease. The basal spike form of the disease does not usually have a direct effect on yield unless it is so severe that there are insufficient healthy shoots to furnish the strings fully.

Leaf infection

Should weather conditions in May favour the disease the leaves of susceptible varieties may be infected. Angular spots develop between the veins, the spots at first being pale in colour, but later turning brown, and spores are produced on the under surface of the leaf. Control measures consist of removing the leaves from the bottom 12 in. of bine when growth has reached about 3 ft., with progressively higher stripping as growth continues, so that when the bine has reached the top wire it is bare of leaves below about 4 ft. 6 in. Under field conditions leaf infection can prove difficult to control, since too drastic stripping is inadvisable as it may weaken the plant; since growth is rapid at this period, copper sprays only give protection for a short time.

Lateral Spikes

If conditions favour the disease, developing lateral shoots may become infected, and the time of onset, severity and duration of this attack can vary greatly from season to season. Control measures consist of the removal of affected shoots and the application of copper sprays. If the attack is early it is not difficult to remove the lateral spikes and there will be no appreciable effect on the yield. In a severe late attack, however, where numerous potential cropping laterals high up on the bine are involved, their removal makes heavy demands on labour and the loss of laterals can lead to a reduction in yield. In a bad year, such as 1956, the heavy production of lateral spikes may continue until vegetative growth stops at the end of July when a good coating of protective copper can be put over all the aerial growth.

Terminal Spikes

The growing tip of the bine may be infected during May or June and the treatment is to cut back the "spiked" bine to a healthy lateral which is then trained up in place of the main bine. This causes a check to growth which may have an adverse effect on yield, particularly if subsequent weather conditions are not favourable for optimum growth.

Cone infection

If copper spraying has been inadequate and weather conditions in August and September favour the disease, the cones may be attacked and turn brown and the entire crop be lost. However, experience shows that heavy and frequent copper sprays will ensure a clean crop even in a bad season, but at a high cost. The Wye Field garden has received such protective sprays of Bordeaux mixture each season so that there is no reliable data on varietal susceptibility to cone infection. In some years, particularly 1952 and 1954 some varieties have been attacked in the cones, but this does not necessarily mean that they are more susceptible than others not affected. In a garden containing varieties ranging from very early to very late it is impossible to apply sprays at the optimum time for all seedlings. Also there is great variation in the amount of bine growth produced and some varieties may become "housed-in" so that the heads receive inadequate spray cover. For these reasons no further reference will be made in this paper to attacks on the cones.

Infection of Straps and Rootstock

In the case of certain varieties the bases of the bines of the past season (known as "straps") may become discoloured, rot, and die during the dormant season and in some cases the rootstock may also die. Such death and rotting appears to be associated with the incidence of Downy Mildew. Though this form of attack was noted in France in 1926 and in this country in 1932 (Salmon and Ware, 1933), nothing is known at present as to how it arises, and no effective control is yet known. With susceptible varieties it may be a major cause of uneven plant and reduced yields. No records are available relating to the presence of affected straps in the trial plots discussed in this paper, but where the infection was associated with weakening or death of hills this has been recorded each season.

SEASONAL VARIATION

Notes on the seasonal incidence of the disease are given below and the numbers of the three types of spikes are given in Table 1.

1950: A generally light attack occurred from May to mid-June.

1951: The total number of spikes per 100 hills was the same as in 1950, but with a higher proportion of lateral spikes. Spiking was carried out from May 10th to July 9th.

- 1952: The attack was heavier due to a substantial increase in the number of lateral spikes; these were particularly numerous during the second half of May and in early June. Spiking was carried out from April 15th to July 14th.
- 1953: There was a low incidence of basal spikes and only a moderate attack of lateral spikes after mid-June. Spiking was carried out from April 14th to July 15th.
- 1954: There was a fairly heavy attack of basal spikes, mainly in the second half of April. There were few lateral spikes and an almost entire absence of terminal spikes. Spiking was in progress from April 14th to July 19th.
- 1955: There were large numbers of basal spikes particularly during April; there was a bad attack of lateral spikes from the end of May with a peak in the third week in June. Spiking was in progress from April 15th to August 11th.
- 1956: The incidence of basal spikes was again severe, particularly at the end of April and in early May. There was an extremely severe attack of lateral spikes, reaching a peak during the third week of June and first half of July. Spiking was carried out from April 18th to August 7th.

SPIKE INCIDENCE IN RELATION TO RAINFALL

As the summer spores of the fungus require moist conditions for their germination, it might be expected that there would be a correlation between summer rainfall and the incidence of spikes. However, a comparison of the figures for number of spikes (Table 1) with the summer rainfall (Table 2) show that whilst in some cases there is a correlation in others it is entirely absent.

Considering basal spikes only, it will be seen that the figures remain low until 1954 and then rise rapidly. Observations made on Goldings at both East Malling (Beard, 1952) and Wye (p. 65 of this report) indicate that even very susceptible varieties remain fairly free from basal spikes in their earlier years, but after a few years the number of such spikes increases rapidly and remains at a high figure. In 1949-52 there was considerable re-planting of varieties in Wye Field and this probably contributed to the low figure for basal spikes before 1954.

The numbers of lateral and terminal spikes present a rather different pattern, being low in 1950, 1951 and 1954, and high in 1952, 1955 and 1956. In some seasons it is possible to trace a

TABLE 1
WYE FIELD HOP DOWNY MILDEW SUMMARY: 1950-56
Seasonal figures for the spike form of the disease

Season	No. of Plots recorded	No. of Hills recorded	Total Spikes			Spike per 100 hills			
			Basal	Lateral	Terminal	Total	Basal	Lateral	Terminal
1950	45	1,812	592	211	78	881	33	12	4
1951	69	2,533	543	628	68	1,239	21	25	3
1952	77	3,128	786	4,034	448	5,268	25	129	14
1953	77	3,073	502	2,610	223	3,335	16	85	7
1954	76	3,037	1,905	570	13	2,488	63	19	1
1955	79	3,118	3,989	9,200	910	14,099	128	295	29
1956	56	2,220	3,704	19,116	658	23,478	167	861	30
									1,058

TABLE 2
SUMMER RAINFALL, WYE, 1950-56 ; DATA EXPRESSED AS INCHES OF RAIN

Month	1950	1951	1952	1953	1954	1955	1956	22-year mean 1935-56
April	(23)* 2.81	(19) 1.99	(15) 1.62	(15) 1.51	(6) 0.26	(11) 0.29	(15) 0.90	1.60
May	(18) 1.37	(23) 2.28	(10) 1.19	(10) 1.66	(15) 1.92	(22) 3.93	(13) 0.75	1.97
June	(8) 1.43	(12) 1.43	(12) 1.26	(17) 3.03	(14) 3.22	(14) 1.97	(22) 2.86	1.73
July	(22) 2.77	(14) 1.17	(10) 0.55	(19) 2.46	(20) 3.33	(6) 1.12	(22) 2.15	2.20
August	(21) 2.45	(21) 5.30	(19) 3.38	(13) 2.19	(16) 3.70	(11) 2.66	(24) 4.04	2.53
September	(25) 2.14	(18) 3.63	(22) 5.19	(14) 4.14	(23) 2.13	(14) 2.05	(15) 1.91	2.31
Total	(117) 12.97	(107) 15.80	(88) 13.19	(88) 14.99	(94) 14.66	(78) 12.02	(111) 12.61	12.34

* The number of days with rain in each month is given in brackets. This figure includes those days when rain was observed but the amount was too small to be measured (i.e. less than .01 in.).

correlation between rainfall and high incidence of spikes, but in others there appears to be none. May, 1951, was rather wetter than normal and the incidence of lateral spikes was about double that in 1950. In 1955, May was very wet and there were large numbers of lateral and terminal spikes which reached a peak in the latter half of June. In 1956 June was wet and there was a very severe outbreak of spikes at the end of the month and in early July. However, in 1952, April, May and June were all dry yet the number of spikes was high; mean maximum temperatures were rather higher than normal, however, and this may have had some effect. In both 1953 and 1954 June was wetter than normal, yet in the first year the incidence of spikes was lower than in 1952 whilst in the second season it was next to the lowest for the seven year period.

VARIETAL DIFFERENCES

The mean annual data (expressed as the number per 100 hills) of basal, lateral and terminal spikes are given in Table 3 for each variety. It will be seen that while no one variety has been entirely free, there are very big variations, the mean totals varying from four spikes in the case of CC77 to 1,518 spikes in the case of Wye Field Golding.

Similarly, though no variety has been entirely free from all forms of spikes, five varieties (CC77, OW131, R20, OX88 and OQ14) have had no basal spikes. With basal spikes the mean annual figure ranges from nil to 332.

In the case of lateral spikes the varietal variation is much greater, ranging from an annual mean of four for CC77 to 1,257 for Wye Field Golding. It will be noticed that there is no correlation between liability to basal spikes and liability to lateral spikes. In the main, high incidence of terminal spikes is associated with a high incidence of lateral spikes, but there is some variation. Although the mean figures show a very big range of susceptibility to spike infection, in a year of severe lateral infection the difference between good and bad varieties is even more striking; for example, in 1956, OR38 and CC77 had nil and two spikes per 100 hills respectively, while at the other end of the scale Wye Field Golding (WFC81) and John Ford (WFA90) had 3,809 and 4,896 spikes per 100 hills.

There is no correlation between incidence of spikes and death or weakening of the rootstock; this is in agreement with earlier observations (Beard, 1937).

TABLE 3
THE INCIDENCE AT WYE OF THE SPIKE FORM OF HOP DOWNY MILDEW AND OF ITS ATTACK ON THE ROOTSTOCK IN
77 SEEDLING HOP VARIETIES CLASSIFIED ACCORDING TO PARENTAGE

Parentage Group	Variety	No. of years recorded	Spikes per 100 hills				Rootstock Attack		Notes on parentage
			Basal	Lateral	Terminal	Total	Weak hills %	Dead hills %	
I. Varieties from Wild Hop, Manitoba.									
(a) First generation.									
	FF8	6	7	11	1	19	0	0	
	X69	6	16	15	0	21	30	5	
	0021	6	18	11	0	29	35	13	
	OV80	6	6	23	1	30	0	0	
	OX88	5	0	34	1	35	42	8	
	R1'38a	6	15	23	0	38	0	0	
	OA59	6	18	23	1	42	0	0	
	OQ22	3	43	15	0	58	0	0	
	OW76	6	53	22	0	75	0	0	
	334a	6	57	30	1	88	0	0	
(b) Second generation.									
	OR38	6	1	5	1	7	0	0	via R3 100.
	AA70	3	5	19	2	26	0	4	via Bullion Hop (Q43).
	WFG66	5	6	34	1	41	0	0	
	ADD4	5	4	36	2	42	40	22	via "Brewer's Gold" (C9a).
	WFB65	6	5	61	4	70	0	0	via Bullion Hop.
	CC23	3	6	101	2	109	23	5	via Brewer's Gold.
	OT100	6	21	94	1	116	10	13	
	OH77	6	99	42	1	142	0	0	via R3 100. "
	OT9	6	12	130	4	145	28	30	via Brewer's Gold.
	OD18	6	253	137	6	396	0	0	via R3 100.
	AOM12	2*	22	373	15	410	0	0	via Brewer's Gold.
	94a	2*	40	579	40	659	13	8	via OL43.
(c) Third generation.									
	WFB16	7	2	8	0	10	0	0	via Bullion and WFC79.
	OW131	5	0	18	2	20	8	2	via Brewer's Gold and III149.
	FF59	7	78	5	0	83	35	5	via 334a and OB53.
	WFD88	7	35	66	22	123	13	5	
	WFB117	7	47	78	13	138	0	0	via "Brewer's Gold" and III149.
	WF153	7	17	339	8	364	28	5	via Bullion and WFC79.
	WFD82	5	275	240	8	523	0	0	via Brewer's Gold and III149.
	WFC130	6	151	386	34	571	0	0	
	OB6	2*	3	622	0	625	5	8	via Brewer's Gold and AEE44.
(d) Canterbury Golding × male from Wild Hop, Manitoba.									
	WFB26	6	4	22	5	31	0	0	
	WFD20	7	23	61	10	94	0	0	
	WFI66	7	66	60	14	140	0	0	
	WFB135 Northern Brewer	7	51	146	18	215	0	0	
	WFB6	5	66	245	29	340	0	0	
	WFI36	7	65	265	24	354	19	29	
	WFG19	7	79	437	52	568	0	0	
	Norton Court Golding	7	97	563	61	721	0	0	
	WFA53	7	115	1,047	31	1,193	0	0	
	WFA90 John Ford	7	115	1,047	31	1,193	0	0	
	WFC81 Wye Field Golding	7	211	1,257	50	1,518	0	0	
(e) Seedlings of Canterbury Golding × male from Wild Hop, Manitoba.									
	OQ14	7	0	66	5	71	0	0	via Wye Field Golding (WFC81)
	WFB4	4	6	65	8	79	25	10	
	DD16	2*	29	348	12	389	0	0	via John Ford (WFA90) "
	WFF90	5	63	425	37	525	0	3	
	WFI94	7	314	687	57	1,058	20	10	via Wye Field Golding (WFC81)
(f) Bramling × male seedling of Wild Hop, Manitoba.									
	OT48 Bramling Cross	4	1	5	5	11	0	0	
	OW92	4	139	80	3	222	0	0	
II. Varieties from <i>H. Americanus</i> var. <i>neo-mexicanus</i> .									
(a) First generation.									
	AOV52	6	2	44	1	47	0	0	
	OZ97a	2	13	1,025	24	1,062	0	0	
(b) Second generation via Y90.									
	OM17	6	3	8	1	12	0	0	
	X111	4	1	38	0	39	0	0	
	OR55 Keyworths Midseason	4	4	155	2	161	0	0	
	R4/40a	6	7	327	6	340	0	0	
(c) Third generation.									
	AOP6	5	11	21	4	36	0	0	via Y90 and EE92.
	AOR43	7	47	18	4	69	0	0	via Y90 and R1/94.
	AOS14	5	82	65	8	155	0	0	
	OJ47 Keyworths Early ..	4	8	366	17	391	0	0	via Y90 and EE92.
	OL53	6	236	654	24	914	0	0	" "
	OL42	6	332	590	22	944	3	5	" "
(d) Bramling × male seedling of <i>neo-mexicanus</i> .									
	DD12	3	66	41	5	112	0	0	
III. Varieties from Oregon Cluster.									
(a) Third generation.									
	CC77	6	0	4	<1	4	0	0	via M45 and OP13.
	HH50	5	23	12	5	40	10	42	via M45 and OQ17.
	ON78	4	3	46	6	55	0	0	via M45 and OP13.
	L11	6	2	207	19	228	20	5	" "
(b) Fourth generation.									
	OK40 Copper Hop ..	6	7	14	7	28	0	0	via M45, OP13 and R1 94a.
	EE14	6	210	107	6	323	0	0	via M45, OQ17 and OF31.
	ADD50	6	71	536	34	641	8	5	via M45, OP13 and L11.
	ACC5	6	102	679	32	813	0	0	" "
(c) Bide's Golden × Oregon male.									
	K31	6	15	87	5	107	3	7	
IV. Seedlings of Fuggle.									
	R20	4	0	24	3	27	0	0	
	OV125	4	78	166	10	254	13	3	
	OR47	4	178	80	4	262	0	0	
	DD57	6	212	90	14	316	8	3	
V. Miscellaneous Seedlings.									
	OT22	6	13	8	0	21	3	5	B20-OS-5
	EE64	3	7	327	25	359	0	0	" "
	OY43	3	78	682	33	793	8	3	Late Bavarian × G13 male

* Records for 1955 and 1956 only: figures for lateral and total spikes may therefore be relatively high.

RELATIVE SUSCEPTIBILITY OF THE PARENTAGE GROUPS (Table 3)

I. *Varieties derived from Wild Hop, Manitoba.*

(a) First generation seedlings: 10 varieties recorded.

Although many of the varieties have borne relatively few spikes, this must not be taken as indicating that all seedlings of this group have a natural resistance to the disease. The parent Manitoba hop was only growing in the experimental gardens for two seasons (1918 and 1919) and it was then that the seedlings were raised and during the course of the years the more susceptible ones have been eliminated. Though only three seasons records are available for the Wye Field plot of OQ22, records for 19 years at East Malling indicate the position of the variety is likely to be correct. Three varieties, X69, 0021, and OX88 have suffered from infection of the rootstock.

(b) Second generation seedlings: 13 varieties recorded.

These exhibit a greater range of susceptibility than the first generation seedlings. One variety, OR38, has been almost entirely free from spikes. Four varieties, ADD4, OT100, AA70 and 94a have suffered from rootstock infection.

(c) Third generation seedlings: 9 varieties recorded.

Here again there is a fairly wide range of susceptibility. WFH16 with a very low mean figure has been entirely free from spikes in four out of seven seasons. It is, however, an "August hop" and usually a poor cropper. Another variety, OW131, has had very few spikes but has suffered, with three other varieties from rootstock infection.

(d) Seedlings of the parentage, Canterbury Golding $\times$ a male (OB 21) seedling of Wild Hop, Manitoba: 20 varieties recorded.

Most of the seedlings of this group have had either moderate or large numbers of spikes. The two worst affected varieties (John Ford and Wye Field Golding) in the garden are of this group. It is interesting to note that Northern Brewer, which is popular with brewers and is being grown on an increasing scale, is markedly less liable to spikes than the other named varieties of this group. WFD20 is, in view of its good Downy Mildew record, worthy of further brewing tests, though it does not have quite as high a Preservative Value as Northern Brewer. Though WFB26 has had the fewest spikes in the group it cannot be considered of promise until its susceptibility to the virus disease "mosaic" is defined. In spite of the fact that this group contains varieties with severe spike infection only one has suffered from rootstock infection.

(e) Second generation from Canterbury Golding $\times$ OB21.

This small group contains a wide range of susceptibility to spikes from OQ14 with a mean of 71 spikes per 100 hills and freedom from basal spikes, to WFI94 with over 1,000 spikes. Three of the five varieties recorded have suffered from rootstock infection.

(f) Bramling $\times$ male seedling of Wild Hop, Manitoba.

Of the two varieties recorded in this group, OW92, has had a mean of 222 spikes per 100 hills (139 basal spikes); the other, Bramling Cross (OT48), has averaged only 11 spikes per 100 hills. Bramling Cross is wilt-tolerant and is being planted commercially. One variety, CC23, derived from Brewer's Gold crossed with a Russian male, has had an average of 109 spikes per 100 hills (101 lateral spikes) and a few hills have died.

II. *Varieties derived from New Mexican Wild Hop (H. Americanus var. neo-mexicanus)*

(a) First generation.

There are now only two varieties in the garden; one, AOV52, has had few spikes, but is of no special interest as it is very late in season. The other, OZ97a, has had a high incidence of lateral spikes for the two seasons that it has been in the garden, but as lateral spikes have generally been very numerous in both seasons, it is likely that the mean number of spikes over a longer period of years would be lower. OZ97a is of special interest as it is wilt-tolerant.

(b) Second generation.

Two of the three varieties in this group have had a low mean total, with very few basal spikes. The third variety, Keyworth's Midseason (OR55), has also had few basal spikes but many laterals. If the variety had been under trial in 1956 it is likely that the mean figure for lateral spikes would have been substantially increased, as observations at East Malling have indicated that this variety is very liable to this form of the disease.

(c) Third generation.

The six varieties exhibit a full range of susceptibility. Of the three varieties absent from Wye Field in 1956, East Malling records show AOP6 to have few spikes, AOS14 to have a moderate number, whilst Keyworth's Early (OJ47) is liable to have many lateral spikes in some seasons. Though AOP6 is fairly free of spikes it is very susceptible to Mould (*Sphaerotheca humuli*). Only one variety has suffered from rootstock infection.

(d) Bramling $\times$ male seedling of *neo-mexicanus*.

The single variety of this parentage has shown moderate liability to spikes over a three-year period.

III. *Varieties derived from the Oregon Cluster*

The Oregon Cluster was one of the early parents used by Professor Salmon and no first or second generation varieties are now growing in the garden.

(a) Third generation.

In the main the six varieties in this group have had few spikes apart from L11 which has had a fair number of lateral spikes. CC77 has had no basal spikes and extremely few lateral spikes and in three out of six years has been entirely free from spikes. It was grown in the East Malling gardens for 14 years and in 9 was free from spikes. CC77 is a generally attractive hop and if found to be acceptable to brewers should have a commercial future. Two varieties, HH50 and L11, have had hills which have been weakened or have died.

(b) Fourth generation.

With one exception, Copper Hop (OK40), all four of the varieties in the group have moderate or heavy spike incidence. One variety, ADD50, has had hills which were weakened or which died.

(c) Bide's Golden $\times$ Oregon male.

The single variety, K31, has not had many spikes but a few hills have been weakened and some have died.

IV. *Seedlings of Fuggle.*

Of the four varieties of this group, one, R20, has shown resistance to the disease with a low yearly average of spikes and has had no basal spikes during a four-year period. Of the other three varieties, two, OR47 and DD57, have had a relatively high number of basal spikes and a very moderate number of lateral spikes, whilst one, OV125, has shown the opposite tendency. Two varieties, OV125 and DD57, have had hills which were weakened and which died.

V. *Miscellaneous Varieties.*

Two varieties derived through a seedling OS99 from a Golding-type hop, B20, found growing in the College hop garden many years ago, have shown very different behaviour. OT22 has had few spikes

but has had a few hills which died, whilst EE64 has had a fairly large number of lateral spikes but the hills have remained healthy. A variety, OT43, derived from the Late Bavarian hop, has had many spikes and had hills which were weakened and died.

Parentage and Rootstock infection

In a previous paper (Beard, 1937) a close correlation between parentage and rootstock infection was noted, being mainly associated with descent from the Oregon Cluster. There are now relatively few varieties of this parentage under test but some of these have suffered from rootstock infection. The highest proportion of varieties with rootstock infection has occurred amongst those derived from the Wild Hop, Manitoba. An interesting group is that of the parentage, Canterbury Golding $\times$ male seedling of Manitoba hop. Here a relatively large group with mainly a high incidence of spikes has had only one variety with rootstock infection. However, in the next generation from this group three out of the five varieties have been affected. Both the earlier East Malling and the present data indicate that varieties derived from the New Mexican hop are markedly free from rootstock infection. At East Malling 35 varieties were all unaffected, whilst at Wye out of 12 varieties only one third generation seedling was lightly attacked.

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THE HISTORY OF A GOLDING HOP GARDEN AT WYE DURING 1949-1956 WITH SPECIAL REFERENCE TO ATTACK BY DOWNY MILDEW (*PSEUDOPERONOSPORA HUMULI*)

F. H. BEARD and DOROTHY M. DERBYSHIRE

SUMMARY

A brief account is given of the history of the first eight seasons of Silks hop garden at Wye College which was planted in 1949 with Early Bird, Eastwell and Petham Goldings, as well as other clonal Golding selections. The garden, which has given high yields of good quality hops, was established on brickearth-type soil that had previously been in pasture for many years.

The yields were initially very high but have shown a downward trend in recent years. This trend has been accompanied by a gradual increase in the severity of attack by Downy Mildew in spite of routine control measures which are described. These have been applied each year to the aerial growth only and have been successful by commercial standards. The trend has also been accompanied by the development of marked unevenness in growth with death of up to 15 per cent. of the hills. These effects have been observed in all varieties but certain varietal differences have been observed and are discussed.

A survey is described of 900 hills which were grubbed in the winter of 1956-57 to make room for new trials. This has shown that nearly 75 per cent. of the rootstocks, none of which was more than eight years old, were rotten to a great or lesser extent. This rotting of the rootstock was associated with the presence of the Downy Mildew fungus in the remaining parts of the hill. Many of the rootstocks contained islands of living tissue among the decayed residue from which the annual growth was produced, this fragmentation accounting for the uneven growth observed.

It is concluded that if such rotting of the rootstock is caused by Downy Mildew, it is not prevented by normal control measures applied during the growing season to aerial parts of the plant. Reference is made to fungicide trials being initiated to investigate the possibility of protecting the rootstock.

INTRODUCTION

Silks hop garden was planted at Wye College in the spring of 1949 on a fertile soil of the brickearth type which had been down to permanent pasture for many years and on which no hops had been grown in living memory. The garden was established to provide an eventual testing ground for a series of clonal Golding selections (Beard and Thompson, 1955) which at that time were still undergoing preliminary trial and required only a small part

of the available acreage. The rest of the garden was planted up with existing clonal stocks of Early Bird, Eastwell and Petham Goldings in three large blocks of just under an acre of each variety. These three stocks were raised and tested at East Malling Research Station and have already been reported on by Beard (1952).

Planting was done with layer cuttings and an excellent take obtained. The plants quickly established themselves and made very strong growth. Those hills which remained healthy have maintained this almost excessively vigorous growth right up to the present time.

The garden has received the normal management given to the College hops and, as is shown in Table 1, high yields have been obtained. While these have fallen off in recent years, the average yield for the seven-year period 1950-56 inclusive is 21.6 cwt. of dried hops to the acre.

TABLE 1
GOLDING HOPS IN SILKS GARDEN
Mean Yields, 1950-56, in cwt. dried hops per acre.

1950	1951	1952	1953	1954	1955	1956
26½	27¼	27½	23¾	18¾	21¾	*5¾

* Yields reduced by extensive gale damage.

ROUTINE MEASURES FOR DOWNY MILDEW CONTROL

Golding hops are known to be particularly susceptible to Downy Mildew both in the aerial parts of the plant and in the rootstock. The control measures in Silks Garden have been primarily directed to produce a disease-free crop of cones at hop picking, and to this end a combination of cultural operations and a programme of copper sprays was used. No direct measures have been taken to protect the rootstocks.

Cultural operations have involved the regular removal of spikes and the stripping off of lower leaves to minimize the spread of infection to healthy tissue. In some seasons the occurrence of large numbers of late lateral spikes has made very heavy demands on the available labour force. For details of seasonal variation in the intensity of the disease, readers are referred to a paper on p. 54 of this report. In general it can be said that 1952, 1955 and 1956 were years with heavy incidence of lateral spikes.

The programmes of copper sprays have been based on Bordeaux mixture applied four times during the season at intervals of 10 to

14 days. The first of these was applied at half-strength when the bines had reached the top wire in late June or early July. The remaining three sprays, all at full strength (10-15-100) were applied at the pre-burr, post-burr and early cone stage. From 1952 onwards the increasing incidence of Downy Mildew led to the introduction of two additional copper sprays applied in June. Copper oxychloride was used for these as Bordeaux mixture even at half-strength caused too much scorching on such early growth. In 1956 an attempt was made to do without these June sprayings, but the incidence of Downy Mildew became so threatening that they were hurriedly applied in the second half of that month.

The main object of the control measures, the protection of the cones, was always achieved. The crops harvested in Silks have not only been heavy; they have also invariably received high valuations, being usually placed in the grade one class and often in the grade one plus bonus class.

INCIDENCE OF SPIKES

Spikes were virtually absent until 1951. In 1951 and 1952 the garden was inspected at frequent intervals and the number of spikes produced by each hill was recorded. In 1953, only the early (basal) spikes were recorded. From this year onwards, the production of spikes was so great that recording their number in the large scale plantings was no longer possible. The incidence of early spikes* from 1951-53 is shown in Table 2. In 1951 spikes were generally few but Early Bird had the lowest number. In 1952 there were generally more spikes and the favourable position of Early Bird was very marked. In 1953 Petham and Eastwell Goldings had about the same number of spikes as in the previous year, and though there was a big increase in the number of spikes produced by Early Bird, the figure was only about half that of the other varieties. The behaviour of the varieties has been very similar to that noted at East Malling (Beard, 1952) though the "build up" has been more rapid.

REPLACEMENT OF HILLS

During the last four years many hills have become weak and some have died. As a result yields have fallen steadily since 1952 as shown in Table 1. It should be noted here that the abnormally low yield of 1956 was due mainly to very severe gale damage. Had

* Observations at East Malling have shown that there is no varietal difference amongst Goldings in the incidence of late infection.

TABLE 2
SILKS HOP GARDEN: INCIDENCE OF DOWNY MILDEW SPIKES, 1951-1953
Spikes per 100 Hills

Variety	1951			1952			1953		
	Basal	Lateral	Terminal	Basal	Lateral	Terminal	Basal	Lateral	Terminal
Early Bird Golding ..	7	3	1	35	95	16	223	Not recorded	Not recorded
Eastwell Golding ..	14	1	1	404	185	19	494	"	"
Petham Golding ..	11	2	0	478	207	24	437	"	"

this damage not occurred, it is estimated that the yield in 1956 would have been of the order of 15-18 cwt. per acre, i.e., below the average of the preceding six years.

Replacement of dead hills has been carried out where necessary and data on such replanting is summarized in Table 3. It will be seen that most replanting has been needed with Eastwell Golding and Early Bird in which 15 per cent. and 11·8 per cent. respectively of hills were replaced during the seven-year period 1950-56. Petham Golding has required far less gapping up with only 4·7 per cent. of hills replaced.

The picture is very similar to that obtained for the East Malling trials (Beard, 1952) though the position of Early Bird and Eastwell Golding is reversed. At East Malling the incidence of dead hills was generally less severe and up to the time of grubbing the garden there, no replanting had been needed in the Petham Golding.

ROOTSTOCK INFECTION

In the winter of 1956-57 about 900 hills were grubbed to make room for comparative trials of some of the newer selections. Approximately equal numbers of hills of Early Birds, Eastwell and Petham Goldings were grubbed. The area involved was one where a number of hills had recently died and growth in general had become weak and very uneven.

Opportunity was taken of this relatively large scale clearance to carry out a survey of the incidence of Downy Mildew in the grubbed hills. These were examined in detail and graded into seven categories as follows:

- (1) Straps brown, hills badly rotten.
- (2) Straps brown, hills partly rotten.
- (3) Straps clean, but hills rotten.
- (4) Straps brown, hills mainly healthy.
- (5) Light infection of straps, hills healthy.
- (6) Clean straps, healthy hills.
- (7) Healthy young hills.

The results, expressed as percentages, are summarized in Table 3. Considering the grading of the grubbed hills it will be seen that all three varieties had a very high proportion of hills with some degree of rotting of the rootstock. The average percentage for all three varieties found in the first three categories is 74 per cent. The

TABLE 3
SILKS HOP GARDEN: GRADING OF GRUBBED HILLS AND NUMBER OF REPLANTS
Values expressed as percentages

Variety	Straps brown hills badly rotten	Straps brown hills partly rotten	Straps clean but hills rotten	Straps brown hills mainly healthy	Light infection of straps	Clean straps healthy hills	Healthy young hills	Replants 1950-56
Early Bird Golding	39.1	41.3	0.3	7.2	6.5*	4.6	1.0	11.8
	80.4			13.7		5.6		
Eastwell Golding	43.9	21.7	1.4	16.3	7.9	7.4	1.4	15.0
	65.6			24.2		8.8		
Petham Golding	46.1	26.1	1.1	13.9	4.8	4.8	3.2	4.7
	72.2			18.7		8.0		

*Including 1.3 young hills.

proportion of apparently healthy hills was under 9 per cent. for all varieties even when young (1 year old) hills were taken into account.

It would appear that although much of the tissue was dead or rotten, new growth arose each season from that portion of the rootstock which was still alive. The rotten tissue resembled peat and in severe cases the hills dropped to pieces as they were grubbed. In badly diseased hills the central crown was often absent or rotten and lateral spread of hill growth had occurred. Thus the hill was no longer in one compact unit but new bines arose each year from islands of uninfected tissue.

In some cases these islands of living tissue were sufficiently widely separated to give the effect of a multiple rootstock. This could be of importance in reducing the efficiency of soil-applied systemic insecticides by making it difficult to ensure that the bases of all bines received treatment.

In other cases young plants were found resting on a totally rotten rootstock. These were probably formed by the rooting of the base of the current year's bine. It was the varying success of this recuperative growth of the hills which gave rise to the uneven vigour characteristic of the growth during recent years.

Considering the varieties separately:

Early Bird. This had a lower proportion of badly rotted hills than the other two varieties, but the combined total of badly and partly rotted hills was the greatest.

Eastwell Golding. This had the fewest rotted hills, though of these a high proportion were so badly rotted that they fell to pieces on grubbing.

Petham Golding. This had slightly more rotted hills than Eastwell Golding but rather fewer hills with infected straps. The figures suggest that the much less replanting needed with this variety was not due to the healthier status of its hills but to its greater ability to regenerate growth from residues of living tissue. It should be noted in this connection that Petham Golding is a vigorous variety with a naturally large rootstock.

A representative collection of strap cuts, including those cuts which did not cut brown, was examined for mycelium of the fungus in the buds after grubbing. The majority of buds, including those of the severely discoloured strap cuts, were not infected, although many of the cushions of tissue from which they arose contained mycelium. In every case where there was an infected bud, mycelium was also present in the tissue beneath. This suggests

that infection of the buds had not occurred from an external source in these strap cuts.

DISCUSSION

After eight seasons approximately 75 per cent. of about 900 hills grubbed from part of Silks garden were more or less rotten despite the fact that hops had not previously been grown on that site, and that routine control measures applied to the aerial parts of the plants were sufficiently effective, to ensure large crops of high quality. During that time spike incidence had greatly increased in association with the development of uneven growth of hills and erratic bine production. The yields of hops also showed a downward trend.

It was necessary in the interests of experimental uniformity to preserve as complete a stand as possible, and in consequence gapping up was only practised when hills actually died. Under conditions of commercial practice it would be preferable to grub weak hills as soon as signs of decay become apparent, before the hills die. Such gapping up with new material would probably involve up to 5 per cent. of the stand annually.

Frequently the discoloured strap cuts and hill tissue containing mycelium were closely associated with the dead parts of the hill, which suggests that the rotting may have been due to Downy Mildew infection. The problem as to whether the mycelium of the fungus is the sole cause of the death of the tissue awaits further investigation.

In such susceptible varieties as Goldings the present measures recommended for the control of Downy Mildew appear to be inadequate to prevent the death of a proportion of the hills if this is due to infection by the fungus. At Wye some preliminary trials have been started in April, 1957, on the replanted areas of Silks garden from which the hills were grubbed. They are designed to study the effect of dusting the hills with Bordeaux powder either at the beginning of the season or throughout the growing period. Captan dust will also be used.

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NOTES ON GROWING HOPS UNDER GLASS DURING THE WINTER OF 1956-57

DOROTHY M. DERBYSHIRE and EVELYN M. DIXON

INTRODUCTION

Unlike many other pathogenic fungi, the Hop Downy Mildew (*Pseudoperonospora humuli*) cannot at present be grown in the laboratory on artificial media. Consequently a supply of sporangia (the infective phase) is only available during the growing season in the field from infected aerial parts of the plant. During the winter there is no readily available inoculum.

With the aid of frames in an unheated glasshouse, and a 16 × 10 ft. glasshouse equipped with lighting and heating, a propagation scheme was started from July, 1956, onwards to provide young hop leaves for inoculation with the fungus throughout the winter. The facilities available did not allow replicated trials of the numerous propagation methods which might have been explored, but information from East Malling and Wye enabled a selection of the most promising.

Vigorous plant growth, including the production of a succession of young leaves, was early found to be essential for the maintenance of the fungus, as attempts to inoculate older leaves of varieties grown in the glasshouse were not successful.

GLASSHOUSE EQUIPMENT

A single glazed, metal framed temporary glasshouse, 16 × 10 ft., was installed with thermostatically controlled electric heating to run at 65° F. during the day and 50-55° F. at night. Artificial lighting was provided by 4 × 500 watt mercury vapour lamps each incorporating a tungsten filament. These were placed along one side of the glasshouse, and used to extend the day-length received by the plants to between 13 and 16 hours per day. The time switch was set to turn the lamps on half an hour before sunset and off at 9.30 p.m. The plants received the extended day-length from September 22nd and heating from October 9th.

TECHNIQUES

The following types of plant material were used:

- (a) Current season's seed.
- (b) Lateral cuttings taken from full length bine.
- (c) Strap cuts from plants grown at Wye.
- (d) Strap cuts from Dr. Roborgh in New Zealand.

(a) *Seed*

Seed was germinated at regular intervals throughout the winter in the heated glasshouse. Prior to germination the seed was placed on moist filter paper in petri dishes for 10 days in the refrigerator at 0-5° C. before sowing in seed compost. Germination was erratic, and occurred over a long period of time, but sufficient seedlings were obtained and grown with an extended day-length. The seedlings were either inoculated at the four leaf stage or allowed to grow on under the lights.

(b) *Lateral cuttings.*

Lateral cuttings were taken from the end of June until mid-September of a number of different varieties and seedlings. In most cases the lower leaves and laterals had been stripped from the bine, and the laterals were therefore obtained from above the 5 ft. level. The cuttings taken in June and July rooted quickly, but those taken in early August did not respond so well. In September the cuttings were treated with a proprietary rooting hormone powder, and gave excellent root growth. Whether this was entirely due to the hormone is uncertain, as no untreated control cuttings were included.

The cuttings were rooted in a mixture of peat and sand, in a cold frame in an unheated glasshouse, burying at least two nodes beneath the soil level. For ten days the frame was kept closed, and shaded from bright sunlight, while the cuttings were frequently syringed with water to keep the leaves moist. After the tenth day the frame was gradually opened until approximately the fifteenth day when the frame light was removed. At the end of three weeks the cuttings were potted on, using John Innes Compost (J11).

The variable growth rate and response to treatment shown by these plants, taken from different varieties, enabled the maintenance of a sequence of growth throughout the winter. Batches of plants were moved from the unheated to the heated glasshouse at intervals and grown under the lights.

The rooted cuttings taken in June and July can be divided into two main categories. In the first group the original growing point of each cutting was present. Plants were either allowed to grow to a height of 7 ft. when growth slowed down naturally, or the growing point was removed at 3-4 ft. The younger leaves of the laterals and sub-laterals which subsequently developed were removed for inoculation, and later these plants were slowly dried off. In certain cases buds from buried nodes began to grow producing a second phase of growth which flourished under the artificial lighting.

In the second group of rooted cuttings in which the terminal bud was absent, either a lateral shoot was produced from the base of the stem or no further growth occurred until buds grew from submerged nodes.

The terminal buds were present after rooting in the majority of the late batch of cuttings taken in September. A second cutting was made of the top part of the shoots after new growth had started and a lateral bud from the bottom node of the original cutting continued growth.

Long shoots of all the plants were grown up strings as in a hop garden, and the diluted major element nutrient solution described on p. 51 was given to the larger plants as they required it from October 19th onwards. Routine precautions were taken against Powdery Mildew, using powdered sulphur, while aphids, red spider, and white fly were controlled with "Metasystox". When the vines growing under the lights became too long to manage, they were either cut back, or trained up strings away from the lights. One of these long vines came into burr on December 25th and bore cones in January. Several others, including vines from two male plants, flowered at the end of March.

Where no further growth appeared after drying off, the plants were either removed to the unheated glasshouse or kept in a refrigerator for 10 days at 0-5° C. before returning to the unheated house. Some of the plants, which received the chilling treatment after November 12th only grew slowly in the heated glasshouse until the end of January, after which the vines grew normally.

(c) *Strap cuts grown at Wye*

Strap cuts taken from the garden in late October and early November were either potted up directly, or left in the refrigerator for 10 days at 0-5° C. before putting them in the warm house. In contrast to cuts taken in January which started into growth

immediately, those taken earlier showed no sign of growth for more than two months. It therefore seems advisable to wait until January before taking strap cuts to provide a fresh supply of shoots, for the new year.

Several of the Bullion strap cuts taken in January produced good shoot growth and came into burr at the end of March.

(d) Strap cuts from New Zealand

After the dormant winter period from May to September in the Southern hemisphere, strap cuts received from New Zealand in October by air from Dr. Roborgh were naturally ready to start into growth, and were planted in the heated glasshouse on October 13th. The first bud appeared above soil level a week later, and these plants provided additional material for inoculation.

RESULT

The object of the scheme was achieved, a succession of young leaves suitable for inoculation with Downy Mildew being maintained throughout the winter of 1956-57. Young leaves so produced were removed from the glasshouse at regular intervals and inoculated with the fungus in the laboratory as described on p. 42.

APPENDIX I

THE CHALLENGE CUPS FOR NEW VARIETIES OF HOPS

F. H. BEARD

The 1956 Exhibition of World Hops, which was organized by Messrs. Wigan, Richardson and Company under the auspices of the Institute of Brewing, included competitions for three challenge cups:

(1) The Brewers' Cup, for hops intended as substitutes for American hops; this cup was presented in 1944 by Messrs. Barclay Perkins, Messrs. Guinness, and Messrs. Whitbread.

(2) The Growers' Cup, for hops intended to augment English commercial varieties; this cup was presented in 1946 by the Association of Growers of the New Varieties of Hops.

(3) The Hop Merchants' Association's Cup, presented in 1949 by this Association for new varieties certified as showing tolerance to *Verticillium* wilt.

The thirteenth series of competitions was held in the show-rooms of Messrs. Wigan, Richardson & Co., 15 Southwark Street, London, on November 27th and 28th, 1956, the judges being Mr. D. G. Le May, Mr. S. H. Morris and Mr. A. E. Quin with Col. F. N. Richardson acting as Chairman of Judges. A list of entries is given below in Tables 1-3 together with the analyses carried out at Wye College, in October and November, 1956, by Mr. E. W. Weston.

The Brewers' Cup (Table 1) was awarded to Messrs. George Nott & Co., Ltd., for a sample of Bullion (Q43) with analyses of 7.18 per cent. alpha resin and 9.81 per cent. beta resins; the second place was given to the same variety grown by Furnace Farms with an analysis of 7.22 per cent. alpha resin and 10.48 per cent. beta resins. The generally poor season is reflected in the low analyses of the winning growths. In 1955 four growths had over 10 per cent. alpha resin whilst in 1956 the best analysis was only 7.8 per cent. alpha resin.

TABLE 1
ENTRIES FOR BREWERS' CHALLENGE CUP, 1956

Variety and Grower	Parish	Hops moisture-free	
		alpha acid %	beta fraction %
<i>Bullion Hop</i> (Q43)			
B. P. Tompsett	Frittenden, Kent	7.80	9.12
†Furnace Farms, Ltd. ..	Paddock Wood, Kent	7.22	10.48
*George Nott & Co., Ltd. ..	Eardiston, Worcs.	7.18	9.81
Wm. Alexander	Eynsford, Kent	6.90	9.89
B. P. Tompsett	Yalding, Kent	6.77	10.54
E. M. Gorst	Paddock Wood, Kent	6.74	10.21
John Turner	King's Pyon, Hereford	6.43	10.77
R. D. Wickham	Brenchley, Kent	6.43	9.82
Tassel Bros. Ltd.	Uckmore, Kent	6.24	9.94
J. A. Worley	Chart Sutton, Kent	6.16	10.23
T. E. Wimshurst	Brenchley, Kent	6.10	9.80
Ditton Court Farm, Ltd. ..	Ditton, Kent	5.78	9.83
J. F. Bomford, Ltd. ..	Fladbury, Worcs.	5.34	9.38
A Guinness, Son & Co. Ltd.	Tepham, Kent	5.12	7.53
<i>Brewer's Gold</i> (C9a)			
R. D. Wickham	Brenchley, Kent	7.07	9.54
Wm. Skinner & Son	East Sutton, Kent	6.78	8.87
E. L. Worsfold	East Sutton, Kent	6.56	9.88
A. Guinness, Son & Co. Ltd.	Tepham, Kent	6.29	9.42
Fremfins, Ltd.	Ashford, Kent	5.37	8.91
<i>Copper Hop</i> (OK40)			
J. F. Bomford, Ltd. ...	Fladbury, Worcs.	5.92	8.56

* Awarded Cup.

† Placed second.

The Growers' Cup (Table 2) was awarded to Messrs. A. & K. J. Ames for a sample of Northern Brewer (WFB135) with an analysis of 0.96 per cent. alpha resin and 8.96 per cent. beta resins. The second place was given to a sample of the same variety grown by Mr. E. L. Worsfold with 7.19 per cent. alpha resin and 8.88 per cent. beta resins. A single entry of the unnamed variety QJ14 (a relative of Northern Brewer) attracted attention on account of the delicacy of its aroma. It is interesting to note that this season there were no entries of John Ford (WFA90) and that the entries of Northern Brewer have increased from 14 to 16.

The Hop Merchants' Association's Cup (Table 3) was awarded to Messrs. G. A. and S. G. Calcutt for a sample of Whitbread's

TABLE 2

ENTRIES FOR GROWERS' CHALLENGE CUP, 1956

Variety and Grower	Parish	Hops moisture-free	
		alpha acid %	beta fraction %
<i>Northern Brewer (WFB135)</i>			
J. & R. Day, Ltd.	Hunton, Kent	9.11	9.45
H. Veall, Junr.	Capel, Kent	8.70	8.74
John Turner	Bosbury, Hereford	8.14	9.84
J. F. Bomford, Ltd.	Fladbury, Worcs.	7.75	9.17
H. Veall & Son	Staplehurst, Kent	7.69	8.69
Wm. Skinner & Son	East Sutton, Kent	7.66	10.11
B. P. Tompsett	Paddock Wood, Kent	7.59	9.74
Wm. Alexander, Ltd.	Eynsford, Kent	7.44	9.00
+E. L. Worsfold	East Sutton, Kent	7.19	8.88
*A. & K. J. Amos	Wye, Kent	6.96	8.69
J. A. Worley	Chart Sutton, Kent	6.54	8.98
B. P. Tompsett	Frittenden, Kent	6.49	9.38
G. A. & S. G. Calcutt	Goudhurst, Kent	6.42	8.08
A. Guinness, Son & Co., Ltd.	Teynham, Kent	6.39	8.09
George Nott & Co., Ltd.	Eardiston, Worcs.	5.97	10.53
J. Dinnis & Sons	Shoreham, Kent	5.53	8.35
<i>Pride of Kent (170a)</i>			
H. Veall, Junr.	Capel, Kent	6.99	13.05
A. & K. J. Amos	Wye, Kent	6.15	12.40
J. F. Bomford, Ltd.	Fladbury, Worcs.	5.89	12.82
<i>OQ14</i>			
A. & K. J. Amos	Wye, Kent	5.46	8.86
<i>ON78</i>			
J. F. Bomford, Ltd.	Fladbury, Worcs.	5.21	7.16
<i>AGG8</i>			
A. Guinness, Son & Co., Ltd.	Teynham, Kent	4.48	7.70

* Awarded Cup.

† Placed second.

Golding Variety (1147) with an analysis of 4.73 per cent. alpha resin and 6.66 per cent. beta resins. Second place was obtained by Mr. D. H. J. Britcher with a sample of Bramling Cross (OT48) giving an analysis of 6.40 per cent. alpha resin and 8.31 per cent. beta resins. Compared with 1955 entries, Whitbread's Golding Variety had increased from seven to eight and Bramling Cross from three to five. There was only one entry of Keyworth's Midseason (OR55).

TABLE 3
ENTRIES FOR HOP MERCHANTS' ASSOCIATION'S CHALLENGE CUP, 1956

Variety and Grower	Parish	Hops moisture-free	
		alpha acid %	beta fraction %
<i>Whitbread's Golding Variety</i> (1147)			
Whitbread & Co. Ltd. ..	Beltring, Kent	5.62	7.71
" " ..	" "	5.45	7.33
" " ..	" "	5.33	7.59
J. A. "Worley" ..	Chart Sutton, Kent	5.18	7.42
C. E. and W. S. Millson ..	Goudhurst, Kent	4.76	7.02
*G. A. and S. G. Calcutt ..	Goudhurst, Kent	4.73	6.66
D. H. J. Britcher ..	Marden, Kent	4.56	7.15
J. A. Worley ..	Chart Sutton, Kent	3.44	5.99
<i>Bramling Cross</i> (OT48)			
†D. H. J. Britcher ..	Marden, Kent	6.40	8.31
J. A. Worley ..	Chart Sutton, Kent	5.13	7.72
Brian H. Day, Ltd. ..	Marden, Kent	5.07	7.75
J. A. Worley ..	Chart Sutton, Kent	4.47	6.75
J. A. Prall & Sons ..	Brenchley, Kent	3.99	6.84
<i>Keyworth's Midseason</i> (OR55)			
D. H. J. Britcher ..	Marden, Kent	6.84	8.44
<i>OZ97a</i>			
Brian H. Day, Ltd. ..	Marden, Kent	4.85	10.19
<i>D1 (E.M.R.S.)</i>			
Brian H. Day, Ltd. ..	Marden, Kent	4.61	6.94

* Awarded Cup.

† Placed second.

APPENDIX II

THE CHEMISTRY OF HOP CONSTITUENTS

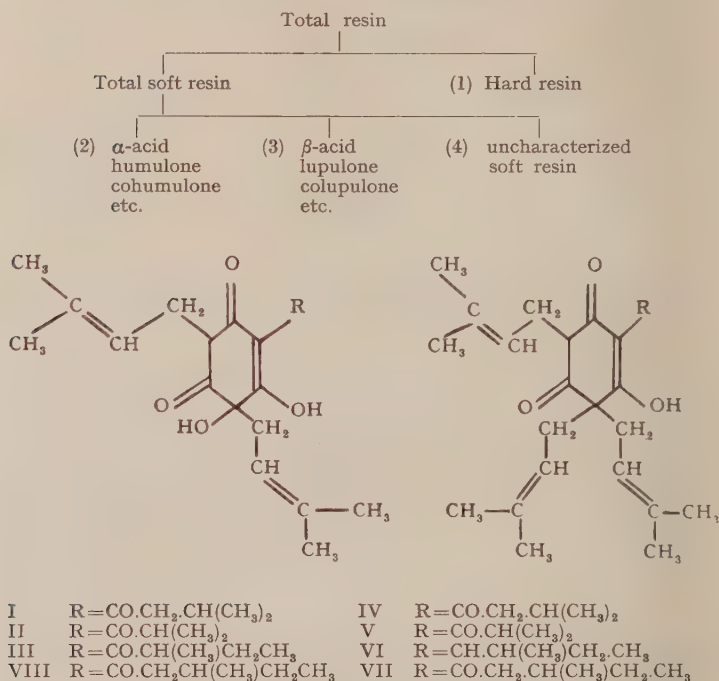
G. A. HOWARD

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In recent years chemical investigations of the hop have revealed the presence of many new constituents and although further advances continue to be made a brief review of the present position would appear to be timely.

The brewing value of hop cones is derived from a wide variety of substances but the foremost characteristic is bittering power for which the hop resins are primarily responsible. These are conveniently divided into four groups (Fig. 1) of which the α -acid is the most important as in practice it accounts for the major part of the bittering and preservative value. Until 1952 it was generally believed that the α -acid consisted almost entirely of humulone (I) but in that year Rigby and Bethune showed, by using the new technique of countercurrent distribution, that in addition to humulone two further compounds, cohumulone and adhumulone, were present (24, 25, 26). The chemistry of these new compounds was elucidated by Howard and Tatchell (11, 12, 13) who also synthesized them by a method first developed by Riedl (21) for the synthesis of humulone itself. It will be observed that cohumulone and adhumulone (II and III respectively) are structurally very closely related to humulone but nevertheless a method more convenient than countercurrent distribution has been devised for determining the composition not only of samples of α -acid derived from different sources (Howard and Tatchell, 16) but also of β -acid and the *iso*-compounds isolated from beer. In the latter connection, when hops are boiled with wort the constituents of α -acid are partially converted into the isomeric substances *isohumulone*, *isocohumulone*, etc. (23, 10) respectively, and it is these which actually are very largely responsible for the bitter taste of beer. The importance of the heterogeneity of α -acid derives from the fact that the conversion of cohumulone in hops to the *isocohumulone* found in beer is more efficient than the corresponding isomerization

FIG. I
THE COMPOSITION OF HOP RESIN



of humulone and adhumulone (23, 19). The bittering power of hops is therefore dependent not only upon the over-all content of α -acid but also upon the detailed composition of this material. Thus the α -acid from Bullion hops, which contains a higher proportion of cohumulone than that of Goldings is the more effective bittering agent on a weight for weight basis. The proportion of cohumulone in α -acid can vary widely but is primarily determined by the variety of hops concerned and is relatively unaffected by manurial conditions, disease or geographical location. For most practical purposes, therefore, it need be determined only once for each variety (Table 1; 14, 17). However, one material factor which affects this general picture is the state of ripeness of the crop when picked (15, 18). During the ripening period the resin content of the cones rises, rapidly at first and then more slowly as full ripeness

approaches. At the same time the relative cohumulone content of the α -acid also rises and usually attains the level characteristic of the variety about a fortnight before picking. It is probably because of this effect, having regard to the American practice of picking the crop in the green state, that the cohumulone content of the α -acid from Bullion hops grown in America is lower than that found when they are grown in this country.

In this connection it is interesting to note that not only do the flowers from male hops contain resin but that the α -acid present appears to contain a proportion of cohumulone like that of the females of similar parentage picked at the same date (17). The assignment of a male hop to a particular class is often difficult and it may well be that the resin composition would be helpful in the classification. That a knowledge of resin make-up is of value with the female plants and should therefore be of use both to the producers and users of hops, can now hardly be doubted.

TABLE I
COMPOSITION OF α - AND β -ACID OF HOPS

Crop	Variety and Source	% Co-component in	
		α -acid	β -acid
1955	Hallertau (U.S.A.)	22	41
1954	Hallertau (Germany)	20	36
1955	Eastwell Golding (Kent)	30	49
1955	Northern Brewer (Kent)	31	47
1954	Fuggle (Kent)	30	48
1955	Fuggle (Kent)	31	48
1955	Fuggle (British Columbia)	28	49
1955	Yakima Early Cluster	39	58
1955	California Cluster	39	58
1955	Pride of Kent (Kent)	40	60
1955	Bullion (Kent)	51	68
1955	Bullion (British Columbia)	42	61
1955	<i>H. americanus</i> var. <i>neomexicanus</i> (Kent)	65	78

Although the β -acid is at present of little value to the brewer it presents features of interest both to the chemist and the hop breeder. As with the α -acid, it was long thought to be substantially homogeneous and to consist of lupulone (IV). Investigations by Howard *et al.* from 1954 onwards (6, 7, 8, 14, 16, 17) showed, however, that it is a mixture of compounds closely related both to one another and to the α -acid constituents. In addition to lupulone, new compounds were discovered which were shown by

chemical degradation and by synthesis to have the structures V and VI respectively and which were accordingly named colupulone and adlupulone. In addition to these three components of β -acid, a fourth having the probable structure VII was also detected (16); its presence has since been confirmed and the compound designated prelupulone (22, 31). Similarly α -acid has been shown to contain a fourth component called prehumulone (30) which is assumed to have the structure VIII. These fourth components of the α - and β -acid occur only in minor amount while traces of still further analogues are probably present.

The proportion of colupulone in the β -acid of a hop is related in a predictable way to the cohumulone content of the α -acid from the same variety (14, 17). The composition of the β -acid appears to be determined primarily by varietal factors although it is affected by the state of ripeness in the same way as the composition of α -acid discussed previously (15, 18).

Besides resin content or bittering power, the brewing value of hops depends to some extent on other factors of which perhaps the most important is aroma. This latter characteristic derives from the essential oils which the analyst obtains by distilling the cones in steam. The material thus obtained varies considerably in amount but on the average represents about 0.6 per cent of the weight of dry hops. It is now known to be very complex (5, 9, 27, 28) in that it contains about fifty compounds (9). Incidentally, less than a dozen of these had been recognized as recently as two years ago. In spite of this complexity the use of the remarkably sensitive technique of gas chromatography (4) is enabling the chemist to learn much about the factors affecting aroma and its possible effect upon the brewing characteristics of the hop. The essential oil of hops is conveniently considered for the moment in two parts, the hydrocarbons and the oxygenated compounds. The hydrocarbons, numbering at least twenty, are of the terpene type and account for from 20 to 70 per cent. of the whole oil, the average being about 55 per cent. (9). The major components are myrcene, caryophyllene and humulene although in some varieties *isocaryophyllene* and *farnesene* make substantial contributions. In general the composition of the hydrocarbon fraction of the oil is determined primarily by variety and thus, even more than by using resin composition, it is often possible to decide the variety by chemical analysis of the oil. Interestingly enough those hops which have a high proportion of "co" component in their α - and β -acids usually also give an oil containing much myrcene in the hydrocarbon

fraction and vice-versa (9, 23, 27). Furthermore the proportion of myrcene in the latter is inversely proportional to that of humulene present. This correlation between the composition of the volatile hydrocarbons and that of the resins is a reflection of the observation that the former changes as the crop ripens, the proportion of myrcene in the hydrocarbons rising as the crop ripens and more oil is produced (9). This is perhaps a first step to explaining by reference to analyses the undoubted change in aroma which is observed in the field.

The oxygenated fraction of hop oil consists of at least twenty-five compounds, many of which are esters although ketones, notably methyl nonyl ketone, are known to be present (9, 27, 29). Although the composition of this fraction appears to be influenced by variety, other factors also appear to be of importance. Amongst these are ripeness and the conditions used in drying the green hops. Over-drying of hops causes loss of oil as would be expected and in particular those compounds, both oxygenated and hydrocarbons, which have the lowest boiling points are lost preferentially. At the same time drying, like storage under poor conditions, apparently causes oxidation of some of the hydrocarbons, notably myrcene, and of certain oxygenated compounds (9). The possibility is thus emerging of determining with some accuracy the effect of different cultural conditions, ripeness, methods of drying and storage upon aroma. The influence of aroma upon the quality of beer will depend in part upon how the hop is used by the brewer. When hops are boiled with wort in the copper, much oil volatilizes with the water and the composition of this volatile material changes continuously as boiling proceeds (5, 9). After two hours, much of the more volatile oil components and with it much of the most characteristic aroma has been lost. That the remainder can, at least on occasion, still affect beer flavour is suggested by the fact that Sunshine hops (boiled two hours in the copper) gave beer with a flavour different from those beers obtained using other potential Fuggles or Goldings replacements (2). This difference was not due to bitterness nor merely to amount of oil and it seems significant that the major dissimilarity known to exist between Sunshine and the other hops examined lies in the high boiling volatile hydrocarbons which are those most likely to be retained after copper boiling (9).

Finally, brief mention may be made of the so-called hop "tannins". Recent work has shown that the "tannin" comprises upwards of eighty compounds which include various flavanols, leucoanthocyanins and substances of the chlorogenic acid type

(3, 20). This insight into the complexity of hop tannin offers hope that the hitherto obscure role of this material in brewing may now begin to be elucidated. Indeed, the rapidly developing knowledge of the chemistry of hop constituents of various types should be of value not only to the brewer but also to those who cater for his needs.

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APPENDIX III

THE 1956 HOP SEASON: WEST MIDLAND PROVINCE

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Seldom does the average yield in the West Midlands exceed that of the South-East, but 1956 was the exception in spite of an average of only 10·3 cwt. per acre. The dry summer of 1955 was followed by a comparatively dry autumn and winter. Spring work proceeded easily but as the weather continued fine and dry, drought conditions, coupled with consistently cold easterly winds, caused growth to be slow and weak particularly where dressing had been late. A severe frost on May 19th caused widespread damage but recovery was fairly general except in some very low lying areas. Although the drought was broken in mid-June, strong winds and low temperatures prevented the hops from growing normally.

The summer became a succession of cold, wet, sunless days that made working conditions difficult and fungus control imperative. In spite of these difficult conditions many yards had a reasonable amount of bine by July and the amount of burr was heavy but only slowly fertilized. The cones, therefore, developed slowly and did not "weigh well" when picked, particularly at the commencement when the hops were generally too green for first quality samples. The effect of using so much wheeled traffic particularly with hop picking machines, on soil in such bad cultural condition, will probably be observed for some time to come.

The short world crop and consequent expected increase in brewers' demand for 1957, caused a very brisk demand for setts (roots) many of which were uncertified. Planting uncertified setts is still a common practice and these have often been responsible for the introduction of disease that cause considerable loss to the buyer. Even a limited guarantee is better than none at all.

PESTS AND DISEASES

The stripping of the lower leaves and laterals by hand to prevent fungus diseases spreading has been practised for many years. A considerable acreage was stripped this year with a

tar-oil type of preparation with very encouraging results. Northern Brewer was observed to throw out new laterals after this method of stripping and this may be a difficulty with some varieties other than Fuggle. Spraying with such materials must be carried out with very great care if serious accidents are to be avoided.

Aphis attack was effectively controlled during the early season by systemic insecticides, but the very windy conditions under which spraying had to be carried out, often left small pockets almost untouched which had to be controlled with "knock-down" sprays later in the season. A slow build up at the end of the season was observed but no serious damage was reported at the time of picking.

Powdery Mildew (Hop Mould) was troublesome in a few places noticeably again on Northern Brewer. Observation trials using "Karathane" in place of sulphur gave encouraging results.

Downy Mildew spikes were not particularly numerous during the early part of the season. With such wet conditions in the latter half of the season it was to be expected that serious outbreaks would occur, and in fact considerable damage was done in a number of cases. Except for the low temperatures there is no doubt that this disease would have reached epidemic proportions since nearly all yards were affected to some degree with Downy Mildew. The Fuggles appeared more susceptible in many areas than had been observed previously.

Botrytis, which is not usually a serious trouble, caused much concern as the crop reached maturity. The actual damage to the crop was relatively slight but very few crops escaped its disfiguring appearance.

Fluctuating Wilt caused more loss than in the previous year, but only a few yards suffered severely. A high proportion of infected plants managed to finish the season without wilting.

Nettlehead (virus) appeared in the early part of the season, to have spread seriously in many existing outbreaks, but during the season little further spread was observed. Completely new outbreaks continue to occur often in most baffling circumstances.

Mosaic (virus) did not appear to be so severe in its toll on the Goldings as in the past few years.

HOP PICKING

At the commencement of picking, the rain "held off" and with a light crop the season was comparatively short and trouble-free. Some 42 per cent. of the growers in the West Midlands already have picking machines and they picked well over 55 per cent. of the

acreage grown in 1956. Unfortunately the machine-picked samples were not always as clean as they could have been since the loss of hop normally associated with clean samples meant, with a short crop, loss of quota.

Some 46 per cent. of the growers in the West Midlands without machines have 10 acres or less of hops. Efforts at co-operative picking have seldom proved satisfactory to all the parties concerned. The introduction and trial of some smaller machines in 1956 and fundamental changes tried in some picking mechanisms, may enable a much smaller machine to be introduced that will meet the requirements of these growers.

DRYING

Some concern during the early part of the season was expressed when many pockets were found to be slightly underdried. The fluctuating and often high humidity increased the drying time required for proper curing and hops on the cooling floor needed constant attention. The difference that exists between machine- and hand-picked hops was again emphasized and disappointment with valuations on some machine-picked growths could not be entirely attributed to the management of the machine. A number of growers expressed complete satisfaction with the elongated thermometers, but one difficulty was encountered when solid fuel automatic stokers were used. The variation in temperature between "cut in" and "cut out" made a true reading at the end of drying very difficult. A method of overcoming this may be found by isolating the automatic control for a short period by a hand-operated "cut in" on the automatic circuit. This would enable a steady temperature reading to be obtained at will.

APPENDIX IV

THE 1956 HOP SEASON : SOUTH-EASTERN REGION

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SEASONAL CONDITIONS

All other aspects of the 1956 Hop Season were overshadowed in the South-East by the exceptional gale of July 29th, and the freak hail storms which occurred in certain localized areas a week later. Prior to this, growth had been a little behindhand following a very late spring. When the snow eventually melted the succeeding weather was bright and sunny, but with a persistent, cold wind from the north-east. This in turn was followed by cold wet weather which continued for the remainder of the summer. Had the growth of the hops been a little more advanced the resulting crop might not have been so badly affected by the gale, but as it was, a high proportion of the hops were caught in burr and consequently never had a chance to produce much crop. The mechanical damage caused was very severe, particularly in East Kent where the wind velocity was highest and the area most exposed. The "heads", which normally bear much of the crop, were largely broken off over the top wire, and the laterals were badly battered. In a number of gardens the wire-work gave way and old lewing was torn to pieces. In addition to the gale damage which was general over the whole region, three areas were severely affected by hail, the biggest of these being the Tonbridge/East Peckham district where many crops were reduced to about 3-4 cwt. per acre. The most severely affected was a small area near Selling in East Kent where some growers had their gardens completely stripped to the bines. The third area, also a small one, lay between Goudhurst and Cranbrook. As a contrast to this general calamity, some growers in the Weald with gardens amply sheltered by natural wind-breaks from the south-west, picked more than their quota. With hops at £35 per cwt. and every one wanted, this was certainly an occasion when the trouble and expense of maintaining adequate natural shelter was fully justified. Mainly as a result of these conditions, the Annual Quota of 95 per cent. was not fulfilled. Over the whole country

75 per cent. was obtained, but in the South-East the proportion was only about two-thirds.

PESTS AND DISEASES

Verticillium Wilt and Nettlehead were the two most important diseases of the year, and a good deal of Split Leaf Blotch was also apparent, even in Goldings, which frequently do not show symptoms. Although the summer was very wet, temperatures were too low for much development of Downy Mildew, although a little was present in many crops. The cold weather favoured *Verticillium* and many outbreaks of Fluctuating Wilt were so severe as to cause some doubt as to their proper category. Progressive Wilt continued to spread in the main affected area, although notifications of new outbreaks were fewer than usual. A single infected hill was found at one of the former outbreaks in North Kent, where a policy of elimination is being followed. Apart from this, and one suspected hill at Wye College at the very end of the season, there were no other cases in this area.

Aphis was rather more difficult to control than usual, since the slow growing conditions of the summer tended to cause a poor uptake of systemic insecticides. Some instances were noted where these had failed to keep pace with bine growth so that the tips became infested. There is now a wider choice of systemic insecticides both for soil application and for spraying, but so far none has established a position of obvious superiority. An unusual pest which occurred locally at two places, was the Rosy Rustic Moth whose caterpillars were found tunnelling the bines. This is not a normal pest, however, and occurs only sporadically.

PICKING AND DRYING

The hops ripened very late and although most growers started picking about September 6th (nearly a week later than normal) this was still too early for the year, and in itself contributed to the very light final yield. Although growers dependent on hand pickers were obliged to start early in order to get their hops picked at all, those with machines did also, partly no doubt for fear of further spread of Downy Mildew should the weather become warm, but also from a general feeling of panic to save what few hops there were before anything else happened. The comings and goings of tractors carting bines over soaking wet land played havoc with the soil and in the absence of any winter frost the effect on subsequent tilth was very marked.

The hopes of small portable picking machines have not materialized, but more stationary machines of various sizes have been installed. There are now about 140 machines in the South-East. The light crop did not really provide a test for modifications introduced since the previous year, and in view of the shortage of hops, growers allowed as much rubbish to go through as they dared. Another year's experience with the prototype continuous drier has led to further modification, and the new type is being offered for sale in 1957. A number of differential thermometers were installed for commercial use and are regarded as a useful adjunct to the drier rather than as an alternative to a skilled man. This must necessarily be so since the exact end-point depends on the rate of approximation of the temperatures above and below the hops as well as on the actual difference in temperatures at a given moment.*

GENERAL PROBLEMS

The major diseases of Progressive *Verticillium* Wilt, Nettlehead (and to a lesser extent Mosaic) and Downy Mildew continued to figure prominently in advisory queries. The conditions for the containment of Progressive Wilt are well known, and this matter is largely in the hand of growers themselves, although any individual grower is affected by the behaviour of his neighbours. The new wilt-tolerant seedlings D1 and D3 were released by East Malling Research Station in the winter of 1956-57 to specialist propagators, but supplies of bedded sets for hop growers will not be available until 1959-60.

Some field experiments to attempt the control of Nettlehead by spraying the hops and headlands with DDT were started in co-operation with East Malling Research Station. Experiments on the effect of dusting the hills with dry Bordeaux powder in an attempt to control Downy Mildew spikes, were continued, but, as in the case of the Nettlehead work, it will be some years before reliable results emerge.

Spraying with urea was tried on hops in grass at three centres in an attempt to overcome the competition of the sward for nitrogen, but the effect (if any) was less than natural variation within the gardens. It appears that the low concentrations of urea which must be used to avoid scorch, together with the relatively small amount of leaf to absorb it, make it impossible to get enough

* 1955 Annual Report, Department of Hop Research, Wye College, page 116.

nitrogen into the plant by this method. Later on, the leaves tend to become hardened by copper sprays and will not absorb the urea. It is now thought that irrigation is likely to provide a more effective method of overcoming this problem.

The manuring of hops is a "hardy annual" among advisory queries, and is usually associated with a request for soil sampling. The level of nutrition required by the crop is becoming clearer as a result of continued experiments, and further evidence is accumulating that the exceptionally high levels of phosphate and potash frequently found in hop gardens are unnecessary. One such hop farm has been studied for the past five years and soil samples taken annually. In this case, no phosphate or potash other than in dung, has been given for the last four years, and the yield of hops has not been reduced. In this case, the levels of phosphate were by no means as high as are frequently found in analyses of hop gardens, although the potash figures were the highest ever recorded here in such samples. It is hoped to continue similar studies at two sites in East Kent, where in general, the levels of available nutrients in hop gardens are very high. The leaflet for growers, "Manurial Recommendations for Hops", has been revised, and will be available for next season as a basis for advice.

APPENDIX V

NOTES ON RECENT PUBLICATIONS AND DEVELOPMENTS IN HOP RESEARCH

(A) ENGLAND

PUBLICATIONS BY STAFF OF THE DEPARTMENT OF HOP RESEARCH, WYE COLLEGE

- R. A. NEVE. "Polyploidy in hops." *Kent Farmer* (Journal of the Kent Branch of the National Farmers' Union), 1956, **5**, no. 9, p. 321.

This general article, written for growers, describes the principles underlying the technique of polyploidy as used in plant breeding research and the application of this technique to hop breeding. It is expected that the use of polyploidy will almost certainly result in better varieties for machine picking and greatly increase the efficiency of breeding programmes designed to produce varieties adapted to the fresh demands of the industry.

Other recent publications by Departmental Staff are as follows:

- F. H. BEARD (with MISS C. L. JARY). "New Varieties. Summary of present position." *Annual Booklet for 1956, Association of Growers of the New Varieties of of Hops*, p. 4.
- H. S. DARLING. "Low volume spraying of new varieties." *Ibid*, p. 32.
- F. C. THOMPSON. "Hops—recent work at Wye College." *J. Inst. Brew.*, 1957, **63**, p. 200.

F. C. THOMPSON.

PUBLICATIONS BY THE STAFF OF EAST MALLING RESEARCH STATION

- R. V. HARRIS. "Progress in research in hop diseases in 1956." *Rep. E. Malling Res. Sta. for 1956*, p. 128.

A review of items of special interest to hop growers.

- P. W. TALBOYS and J. F. WILSON. "A study of wilt-tolerance in the hop by means of intervarietal graft complexes." *Rep. E. Malling Res. Sta. for 1955*, p. 126.

In experiments to supplement earlier work on host-parasite relations by grafting methods, it has been shown that the action

of the hop root-system in determining the severity of *Verticillium* Wilt symptoms does not result from the translocation of specific "resistance" or "sensitivity" factors.

J. F. WILSON. "Whitbread's Golding Variety: a note on wilt-tolerance in the field and the establishment of a *Verticillium*-free planting stock." *Rep. E. Malling Res. Sta. for 1956*, p. 128.

Field studies of Whitbread's Golding Variety grown under commercial conditions in different localities show the wilt-tolerance of the variety to be satisfactory and comparable with that of Keyworth's Midseason. A stock of the variety shown by test to be free from *Verticillium* has been established and distributed to commercial propagators.

F. C. THOMPSON.

PUBLICATIONS BY THE MINISTRY OF AGRICULTURE, FISHERIES AND FOOD

"Hop Growing and Drying." Bulletin No. 164 of the Ministry of Agriculture, Fisheries and Food. 62 pages. Published in 1956 by Her Majesty's Stationery Office, London. Price 5s.

The welcome appearance of this bulletin meets a much-felt need. Its predecessor, entitled "Cultivation, diseases and pests of the hop crop," published in 1925, has long been out of print, and for many years there has been no authoritative work on English hop production available to those requiring information on the industry. This bulletin will excite interest, therefore, not only on account of its merits which are considerable, but because it is the only publication of its kind. Its main author is Dr. A. H. Burgess, formerly head of the Department of Hop Research at Wye College. Sections on diseases and pests have been contributed respectively by Dr. H. H. Glasscock and Mr. B. D. Moreton, of the National Agricultural Advisory Service.

The bulletin is well written and produced and is helpfully illustrated by 39 clear photographs, drawings and diagrams. It covers all aspects of hop production, including marketing. The experience gained in many years of study of the crop is apparent in the skill and sense of proportion with which Dr. Burgess has selected and presented his data. Each topic is discussed in a lucid manner which permits of easy understanding by the novice and yet makes worth-while reading for the experienced grower.

The value of some sections of the bulletin is unfortunately

reduced by an apparent delay of three or four years between the writing of the text and the appearance of the finished publication. This has had the effect of making some of the subject matter out of date before it reached the public. This effect is obvious in the section on picking where the most recent reference is dated 1952 and no mention is made of the report on hop picking by machine, written by Mr. G. P. Chater and Miss C. L. Jary, which was published in 1955. It is also apparent in the chapter on hop nutrition where the levels of phosphatic manuring recommended are higher than those which recent research has shown to be necessary in an English hop garden of normal high fertility. Similarly the statement on p. 28 that "the hop is sensitive to soil acidity" is at variance with recent work at Wye which has shown that this crop is relatively tolerant of soil acidity and under English conditions probably does best at a soil pH of 5.5 to 6.0. Furthermore, the brief discussion on hop analysis on p. 40 makes no reference to the major advances in hop chemistry which have resulted from recent work at the Brewing Industry Research Foundation.

The chapters on diseases and pests appear to have been written shortly before publication and therefore escape any criticism of being out of date. They give a very adequate account of the pathological and entomological problems facing the hop grower, and control measures are clearly and specifically discussed.

H. S. DARLING.

(MISS) C. L. JARY and G. P. CHATER. "Machine picking of hops". *Agriculture*, 1956, **63**, p. 224.

This up to date account discusses possible developments in machine picking. Further developments are likely to depend partly on whether new machines can compete directly with the existing large stationary machines, either in economy or in efficiency of operation, and partly on their suitability for the smaller grower. Reference is also made to the introduction of a system of continuous drying in conjunction with machine picking.

F. C. THOMPSON.

PUBLICATIONS BY THE INSTITUTE OF BREWING

INSTITUTE OF BREWING HOPS ADVISORY COMMITTEE. "Institute of Brewing Hop Trials: 1954 Crop." *J. Inst. Brew.*, 1956, **62**, p. 304.

Considering this year's results in conjunction with those of previous seasons, D3 appears to be a satisfactory hop for replacing

at least 25 per cent. of the normal hop grist and, although its dry hopping qualities should not be emphasized, it has found favour in this respect with most of the brewers who have tested it. D1, which showed high promise in the small-scale trial from the 1952 crop, has not been quite so readily acceptable in this season's trials but, nevertheless, it is a promising variety. J2 also shows promise and is acceptable, up to at least 25 per cent. replacement, by the five brewers who have tested it this season. In previous trials OT48 has not appeared to be as acceptable as the above-mentioned varieties, possibly on account of its slight American aroma, but in this year's trial, which was on a smaller scale than usual, it appears to be more acceptable. V94, which was previously tested in 1951, does not appear to be a variety which brewers are likely to accept and there is little doubt that C2 would be unacceptable as a replacement for Fuggles by most brewers.

J. I. WEBB. "Institute of Brewing trials with Wye Variety Hops, 1952 and 1954." *Annual Booklet for 1956, Association of Growers of the New Varieties of Hops*, p. 12.

This account of trials organized by the Hops Advisory Committee of the Institute of Brewing gives results previously published in the *Journal of the Institute*. This paper is brought to the attention of growers, however, as the booklet of the A.G.N.V.H. is likely to be more readily available to them—obtainable from Mr. P. W. Chambers, Hon. Secretary, A.G.N.V.H., Langley Park Farm, Langley, Maidstone, Kent, price 4s. to non-members.

F. C. THOMPSON.

(B) RESEARCH IN OTHER COUNTRIES

F. C. THOMPSON

GERMANY

Judging from reports in the literature, hop research in Germany is being intensified and among the papers noted, but which it has not been possible to consult in detail at the time of writing, are the following:

- BUCHER. "The start of more extensive soil research in hop cultivation." *Hopfen Rundschau*, 1957, **8**, no. 3, p. 29.

ANON. "New Tasks at Hüll (the German Hop Research Station)—an account of the session of the Executive and Technical-Scientific Committee and of the Members' Meeting of the German Society for Hop Research." *Deutsche Brauwirtschaft*, 1957, **66**, no. 9, p. 97.

Nevertheless, it would appear that the German hop industry may be handicapped by the occurrence of a Wilt Disease which, from the information available, may be akin to the hop wilt found in England. The first published reference to this trouble was seen in the following paper:

F. ZATTLER. "The Wilt Disease of hops." *Hopfen Rundschau*, 1957, **8**, no. 1, p. 6.

From the information given in this paper, the disorder is attributed to weak fungal parasites and to eelworms together—the primary organism is not known. Wilting is said to be worst on old soils and under conditions of waterlogging, high nitrogen supply and soil acidity. As yet, the total area of affected land is not great, but is confined to small patches in a number of gardens. A Working Party has been set up to investigate the disease, and a Plant Pathologist and an Entomologist have been appointed to work on the problem under the direction of Professor Zattler.

Two more recent publications on the problem, which it has not yet been possible to consult in detail, are the following:

F. ZATTLER. "On Wilt Disease and other danger points in our hop culture." *Brauereitechniker*, 1957, **9**, no. 7, p. 49.

ANON. "Energetic combat against Wilt Disease: Intensified research at the Hüll Hop Research Station." *Brauerei*, 1947, **11**, no. 33, p. 175.

BELGIUM

F. HOED, P. ELSOCHT and J. HOED. "Belgian National Hop Institute. Report on investigations and trials carried out in 1956." Brussels, 1956.

The report covers variety trials, fertilizer experiments, studies on the botanical structure of different varieties, trials with new insecticides and fungicides, drying experiments and brewing trials. Among these items it is of interest to note that the Wye variety, Northern Brewer, continues to do outstandingly well in field trials in comparison with the well-known commercial Continental varieties Hallertau and Saaz.

CZECHOSLOVAKIA AND RUSSIA

Research appears to be active in the well known "Saaz" hop growing district in Czechoslovakia, and this country has recently been elected a member of the Scientific Commission of the European Hops Culture Committee. Investigations on hop picking machines are an important aspect of the work in this country.

Hop research is also carried out in Russia and in the following paper a somewhat startling claim is made that completely perennial hops have been produced, though the practical value of this finding is open to question.

NEČIPORČUK, J. D. "The problem of altering hops by means of training." *Doklady vsesojuz Akad. selsjk. Nauk.*, 1956, **21** (6), p. 15. Through "Horticultural Abstracts".

To simplify hop cultivation attempts were made at the Lvov Agricultural Institute to transform the annual stems into perennial ones. This was accomplished by enclosing a growing stem for a season in a tarred paper tube with only 2-3 pairs of the upper leaves showing. Plants with perennial stems are now in their fourth year. They produced annual sideshoots which are shorter than shoots of the normal hop plant.

U.S.A.

J. F. TEMPLIN. "Comparative tests regarding the effect of sulphuring on the bittering power of hops." *Amer. Brewer*, 1955, **88**, no. 5, p. 50.

Early Cluster hops, dried without sulphur treatment, had a higher bittering value than similar sulphured samples. This result was not found with Late Cluster hops, however, and the author concludes that the effect of sulphuring on bittering power depends largely on the variety of hop used.

E. L. DAVIS. "Typing Hop Samples by microscopic techniques." Paper presented at the 69th Anniversary Convention of the Master Brewers Association of America, Chicago, Sept., 1956.

An examination of the botanical structure of some well-known hop varieties suggests that Saaz, Hallertau, Tettngang and Styrian hops are closely related and differ appreciably from Fuggles and Brewer's Gold.



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